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Washington DC 20460

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Cincinnati OH 45268

Superfund

EPA/540/G-85/002 June 1985

EPA

Guidance on Remedial Investigations Under CERCLA

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EPA/540/G-85/002
June 1985

Guidance on Remedial Investigations Under CERCLA

Prepared for:
Hazardous Waste Engineering Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

and

Office of Emergency and Remedial Response
and
Office of Waste Programs Enforcement
Office of Solid Waste and Emergency Response
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I

NOTICE

The information in this document has been funded, wholly or in part, by the United States Environmental Protection Agency under Contract No. 68-03-3113 to JRB Associates. It has been subject to the Agency's peer and administrative review and has been approved for publication as an EPA document.

This handbook is intended to present guidance on the conduct of remedial investigations to obtain data to evaluate and select measures to control specific problems caused by uncontrolled hazardous waste sites.

FOREWORD

Under the authorities of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), the Office of Emergency and Remdial Response and the Office of Waste Programs Enforcement are responsible for overseeing the development and implementation of the Government's program for response to uncontrolled releases of hazardous substances. These responses ensure that threats to public health, welfare, or the environment are appropriately addressed through the effective management of CERCLA's enforcement and funding authorities. The Hazardous Waste Engineering Laboratory develops new and improved technologies and systems to prevent, treat, and manage hazardous waste pollutant discharges to minimize the adverse economic, social, health, and aesthetic effects of pollution.

This document is a cooperative effort between the Office of Solid Waste and Emergency Response and the Office of Research and Development. It is one of a series of reports being published to implement CERCLA, otherwise known as Superfund. These reports provide an array of information necessary for compilance with the National Contingency Plan (NCP, 47 FR 31180, July 16, 1982), including: guidance for remedial investigation and feasibility studies, guidance for exposure assessments, analytical and engineering methods and procedures, research reports, technical manuals, toxicological and engineering data bases, and other reference documents pertinent to Superfund.

This guidance document provides guidance on the conduct of remedial investigations in support of feasibility studies under Superfund and the National Contingency Plan. It describes the requirements which need to be met to obtain valid data which are necessary and sufficient to determine what response actions, if any, can be considered, evaluated, and applied to mitigate impacts on public health, welfare, and the environment posed by the site. This document describes the essentail steps in the remedial investigation process and identifies important factors, information, and analysis needs to scope the investigation; prepare all necessary plans (health and safety, sampling, data management); conduct the site assessment; and evaluate and present results. The guidance document provides government and private personnel with the means to plan, prepare, conduct, and conclude remedial investigations consistent with hazardous waste site clean-up legislation and site-specific requirements.

ABSTRACT

This guidance document is intended to provide a more detailed structure for field studies involving data collection for remedial decisions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (40 CFR 300).

The remedial investigation emphasizes data collection and site characterization and is conducted concurrently with the feasibility study. The remedial investigation also supports remedial alternative evaluation and design through bench and pilot studies.

The initial activity in the remedial investigation is the scoping process. The scoping effort includes the collection and evaluation of existing data, identification of remedial investigation objectives, and the identification of general response actions for the feasibility study. The effort also identifies preliminary plans, and investigation tasks are identified.

A variety of activities supporting the remedial investigation may require the preparation of specific plans or implementation of specific procedures. These include preparing a sampling plan; identifying data management procedures; planning for health and safety needs; and identifying and reviewing institutional issues arising from Federal, State, and local regulations, policies, and guidelines.

The site characterization process is the focal point of the remedial investigation and involves the collection and analysis of the data needed for the various types of assessments that are part of the investigation. Because site data and understanding vary, a multilevel approach to data collection is recommended: Level I, problem identification and scoping; Level II, problem quantification; and Level III, problem quantification and detailed investigation. The focus, data needs, and data evaluations conducted at each level of the investigation are described for each type of assessment.

Bench- and pilot-scale studies may be needed in the remedial investigation to obtain enough data to select a remedial alternative. The scope of these bench and pilot studies address waste treatability, scale-up of innovative technologies, technology application issues, and evaluation of specific alternatives.

A recommended format for the Remedial Investigation Report is also provided. It describes the specific elements to be included, the rationale for their inclusions, the level of detail, and the documentation that should accompany the report.

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[1] Currently with Clean Sites, Inc.

CHAPTER 1

INTRODUCTION

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) not only established a Fund (commonly known as Superfund) for financing the cleanup of uncontrolled hazardous waste sites, it also required that procedures be established to evaluate remedies, to determine the appropriate extent of the remedy, and to ensure that remedial measures are cost-effective. Such remedial measures must, to the extent practicable, be in accord with the National Contingency Plan (NCP). For Superfund-financed sites, the need to protect public health, welfare, and the environment at a specific site must be weighed against the ability of the Fund to finance remedial action at other sites posing other threats to public health, welfare, or the environment.

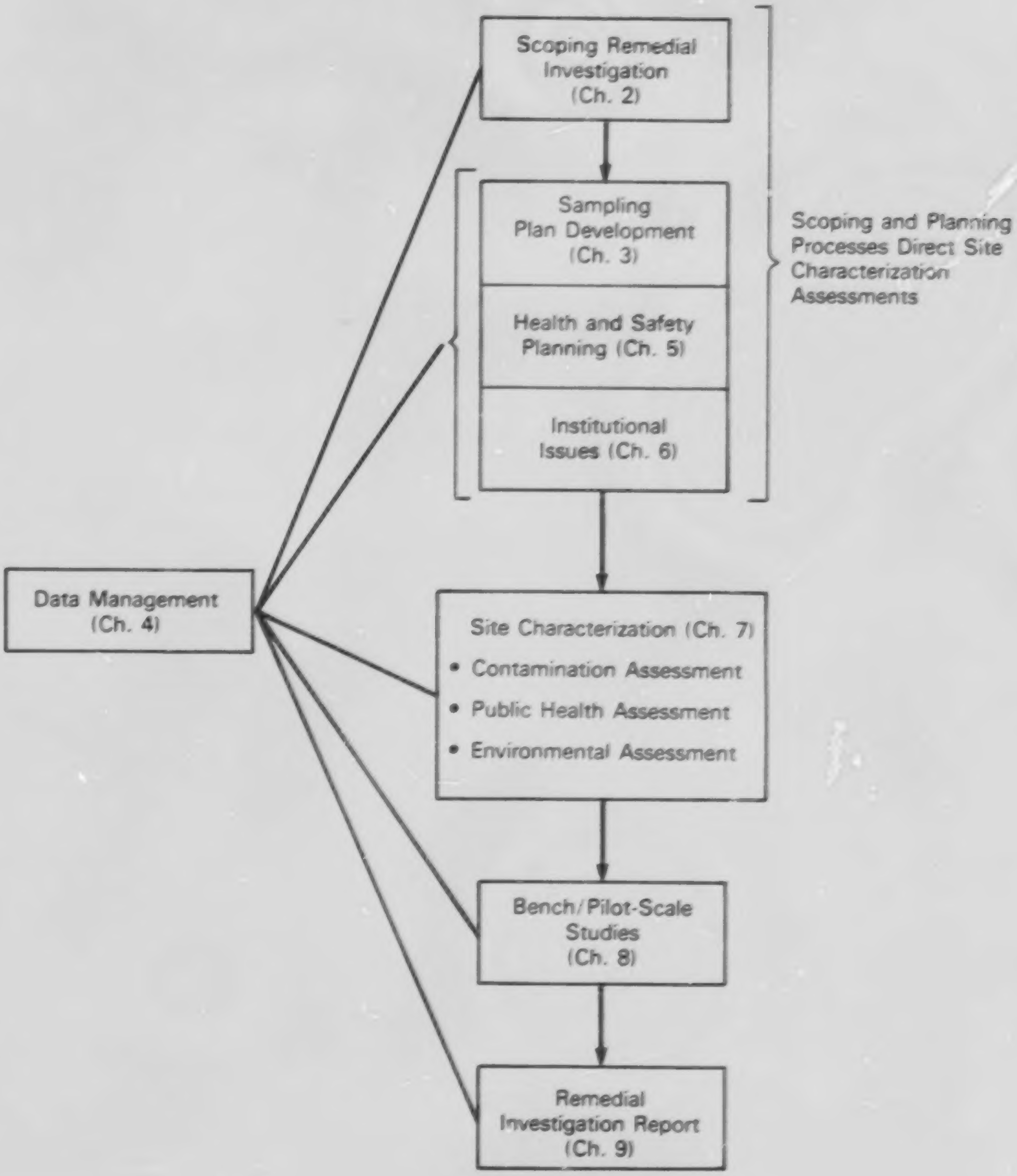
The U.S. Environmental Protection Agency (EPA) has the authority and responsibility for carrying out these provisions under CERCLA. The plan for enacting these provisions appears in the revised National Contingency Plan (47 FR 31180, July 16, 1982; 40 CFR 300) as Subpart F (40 CFR 300.61-300.71). The NCP describes the evaluation and selection of remedial actions.

Within the framework of the NCP, this guidance document provides Regional Project Officers with a more detailed structure for field studies involving data collection for remediation decisions. At Superfund sites where enforcement actions are taken, or where claims against the fund are made, remedies consistent with the NCP must be found. Therefore, this guidance should also be used in conducting investigations supporting enforcement and litigation. Private parties involved in hazardous waste management may also find this document helpful.

1.1 OVERVIEW OF THE REMEDIAL INVESTIGATION PROCESS

The remedial investigation emphasizes data collection and site characterization. Conducted concurrently with the feasibility study, the remedial investigation is the data collection mechanism for the feasibility study effort; this relationship is discussed further at the end of this chapter. The remedial investigation also supports remedial alternatives evaluation through bench and pilot studies. Figure 1-1 illustrates the remedial investigation process and keys chapters within this document to the parts of the remedial investigation.

Figure 1-1. Remedial Investigation Process


Scoping Remedial Investigation (Ch. 2)
Sampling Plan Development (Ch. 3)
Health and Safety Planning (Ch. 5)
Institutional Issues (Ch. 6)
Scoping and Planning Processes Direct Site Characterization Assessments
Data Management (Ch. 4)
Site Characterization (Ch. 7)
• Contamination Assessment
• Public Health Assessment
• Environmental Assessment
Bench/Pilot-Scale Studies (Ch. 8)
Remedial Investigation Report (Ch. 9)

The initial activity in the remedial investigation is the scoping process. The scoping effort includes the collection and evaluation of existing data, identification of remedial investigation objectives, and the identification of general response actions for the feasibility study. Data needs, preliminary plans, and investigation tasks are identified. The investigation scoping process may recur or be modified as more data are collected and site characterization becomes more complete. Details of the scoping process are addressed in chapter 2.

The scoping process is critical to the development of a sampling plan and subsequent remedial investigation. Chapter 3 provides detailed guidance on developing this plan and on the required level of effort. This sampling plan describes the sampling studies to be conducted, including sample types, analyses, and sampling locations and frequency. Planning needs such as sampling operational plans, materials, record-keeping, sampling team personnel needs, and sampling procedures are also developed or identified for the investigation.

Associated with the scoping and sampling plan efforts are a variety of support activities that may require the preparation of specific plans or implementation of specific procedures to supplement the remedial investigation and documentation of data. Discussions of these activities appear in chapter 4, which addresses data management procedures, including quality assurance/quality control programs; chapter 5, which summarizes health and safety planning requirements, including development of an overall health and safety program and a site-specific health and safety plan; and chapter 6, which reviews institutional issues arising from Federal, State, and local regulations, policies, and guidelines that may affect the investigation.

The site characterization process, the focal point of the remedial investigation, is described in chapter 7. Site characterization involves the collection and analysis of the data needed for the various types of assessments that are part of the investigation. This chapter also describes the focus, data needs, and data evaluations conducted at each level of the investigation for each type of assessment.

Because site data and understanding vary, a multilevel approach to data collection is recommended. Each level differs in the scope of the activities. The three levels of data collection and site characterization efforts are:

- Level I - Problem Identification and Scoping. Existing site information is collected and evaluated to define the problem(s) at the site, public and environmental threats, and site features contributing to the problem(s). This assessment is conducted for all sites and provides the basis for immediate mitigation actions for defining investigation needs in levels II and III. The data collected at this level are also used in identifying and analyzing remedial technologies.

- Level II - Problem Quantification. Specific site data are collected through sampling and field studies to characterize site problems and their dimensions more fully. Sufficient data should be collected to identify contaminants of concern, to verify actual exposure pathways, and, in general, to characterize the site well enough to support, at a minimum, the screening of remedial technologies and alternatives.

- Level III - Problem Quantification and Detailed Investigation. If level II data are insufficient, additional data are collected for use in detailed analysis of remedial alternatives or in the selection of a cost-effective alternative.

The remedial investigation does not require that all three levels be completed; the process may terminate at any level provided that sufficient data have been obtained. For some sites, a level I study may furnish enough data for response decisions, particularly if a site has been well-studied or the need for an immediate response is obvious. The investigation may end at level II if characterization data are sufficient to permit the selection of a response. Alternatively, where level I analyses are sufficient to support feasibility study decisions and a level II effort is not necessary, a level III study involving bench or pilot testing may be needed to select between alternatives or finalize a design. Thus, the investigation needs vary from site to site, and the levels of the remedial investigation must be appropriate to these needs.

Bench- or pilot-scale studies may be needed in the remedial investigation to obtain enough data to select a remedial alternative. The scope of bench and pilot studies in the remedial investigation specifically address waste treatability, scale-up of innovative technologies, technology application issues, and evaluation of specific alternatives. Bench and pilot studies may also be conducted during remedial alternative design or construction to more fully evaluate specific requirements of the selected alternative, however, these studies are outside the remedial investigation and feasibility study process. In general, bench-scale studies are appropriate for the remedial investigation stage while pilot-scale studies, if required, may be conducted during the final design. Chapter 8 describes the analysis of the need for bench and pilot studies in the remedial investigation, the requirements of these studies, and data analysis procedures.

Chapter 9 discusses the recommended format for the Remedial Investigation Report. It describes the specific elements to be included, the rationale for their inclusion, the level of detail, and the documentation that should accompany the report.

Before turning to the details of the remedial investigation process, several overall points should be emphasized:

1. The remedial investigation is the data collection activity for the feasibility study; through bench and pilot studies, it supports the remedial alternative design effort as well.

2. The remedial investigations must be conducted consistently with the process set forth in the National Contingency Plan.

3. Data needs differ between enforcement-lead, fund-lead, and private party-lead remedial investigations. The data collection process must be tailored to meet specific investigation needs and objectives, including data quality and sufficiency.

4. All supporting files and supporting documentation must be collected and retained.

1.2 RELATIONSHIP BETWEEN THE REMEDIAL INVESTIGATION AND THE FEASIBILITY STUDY

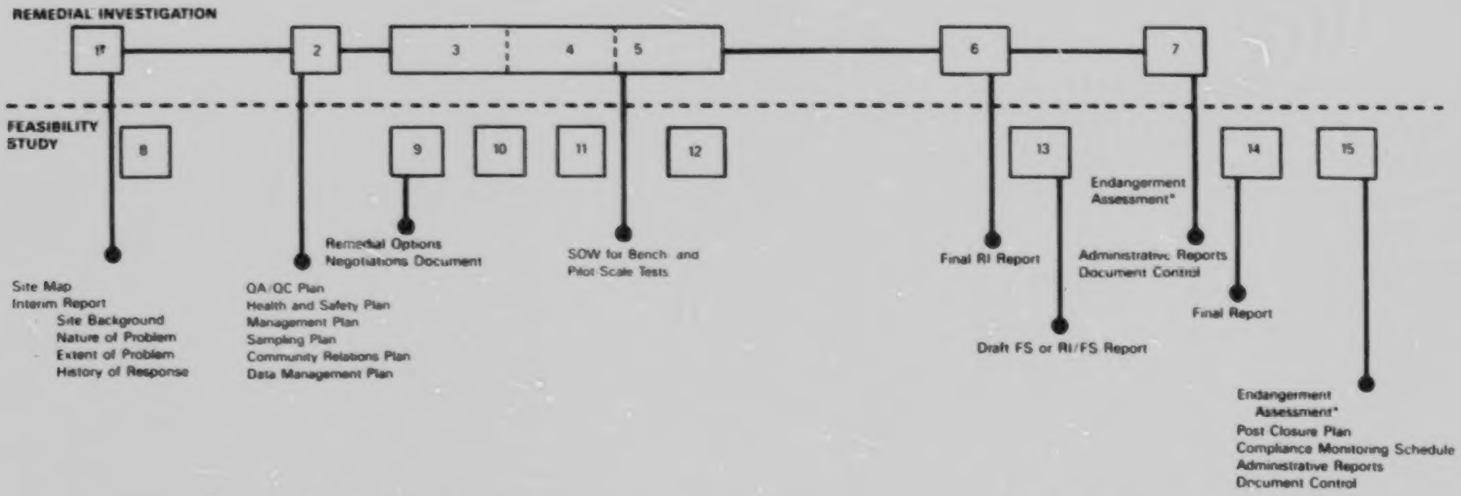
The user should also recognize that the remedial investigation and the feasibility study are interdependent. The activities comprising these two projects are generally performed concurrently rather than sequentially. The remedial investigation emphasizes data collection and site characterization, whereas the feasibility study emphasizes data analysis and decisionmaking.

Figure 1-2 depicts the concurrent activities associated with the remedial investigation (RI) and feasibility study (FS). The upper portion of the figure consists of two flow charts illustrating the sequential, interdependent events associated with the RI/FS process. The lower portion of the figure is a tabulation of the tasks identified in the Model Statement of Work for the RI/FS. This Model Statement of Work sets forth the tasks that a contractor will perform in conducting a government-lead RI/FS and is included in this document as Appendix A. The lower portion of Figure 1-2 also identifies the chapters in the Remedial Investigation and Feasibility Study Guidance Documents corresponding to the tasks in the Model Statement of Work. The numbers in the boxes of the flow charts correspond to the individual RI/FS tasks listed in the Model Statement of Work.

The vertical lines on the chart indicate some of the plans, reports, or milestones recommended in the RI/FS guidance. These connectors and the listings below them illustrate the integration of the RI/FS process.

Management and coordination of RI/FS activities will affect the resources, timing, and completeness of the RI and FS reports. Site-specific conditions will govern the extent of data collection and analysis for each level of the RI and FS process. It must be emphasized that the objective of this guidance is not to instruct the user in specific methodologies for conducting the remedial investigation, but instead to provide direction for the overall process.

Figure 1-2. RI/FS Process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Interim Report
Site Background
Nature of Problem
Extent of Problem
History of Response
QA/QC Plan
Health and Safety Plan
Management Plan
Sampling Plan
Community Relations Plan
Data Management Plan
Remedial Options
Negotiations Document
SOW for Bench- and
Pilot Scale Tests
Final RI Report
Draft FS or RI/FS Report
Endangerment
Assessment*
Administrative Reports
Document Control
Final Report
Endangerment
Assessment*
Post Closure Plan
Compliance Monitoring Schedule
Administrative Reports
Document Control

Remedial Investigation

Model Statement of Work for Remedial Investigations

- Task #1 - Description of Current Situation
- Task #2 - Plans & Management
- Task #3 - Site Investigation
- Task #4 - Site Investigation Analysis
- Task #5 - Laboratory & Bench Scale Studies
- Task #6 - Reports
- Task #7 - Community Relations Support

Guidance Document for Remedial Investigations Under CERCLA

- CH 1 - Introduction
- CH 2 - Scoping
- CH 3 - Sampling Plan Development
- CH 4 - Data Management Procedures
- CH 5 - Health and Safety Planning for Remedial Investigations
- CH 6 - Institutional Issues
- CH 7 - Site Characterization
- CH 8 - Pilot and Bench Studies
- CH 9 - Remedial Investigation Report Format

Feasibility Study

Model Statement of Work for Feasibility Studies

- Task #8 - Description of Proposed Response
- Task #9 - Preliminary Remedial Technologies
- Task #10 - Development of Alternatives
- Task #11 - Initial Screening of Alternatives
- Task #12 - Evaluation of Alternatives
- Task #13 - Preliminary Report
- Task #14 - Final Report
- Task #15 - Additional Requirements

Guidance Document for Feasibility Studies Under CERCLA

- CH 1 - Executive Summary
- CH 2 - Develop a Range of Remedial Alternatives
- CH 3 - Conduct a Detailed Technical Evaluation
- CH 4 - Evaluate Institutional Requirements
- CH 5 - Evaluate Protection of Public Health Requirements
- CH 6 - Evaluate Environmental Impacts
- CH 7 - Cost Analysis
- CH 8 - Summarize Alternatives
- CH 9 - Feasibility Study Report Format

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† Numbers in the boxes refer to tasks described in the Model Statement of Work for RI/FS under CERCLA Guidance issued February 1985. See Appendix A.

* Endangerment assessments may be prepared at any point in the RI/FS process in support of enforcement actions.

6

CHAPTER 2

SCOPING

2.1 INTRODUCTION

The National Oil and Hazardous Substances Contingency Plan (NCP) (47 FR 31180, July 16, 1982; 40 CFR Part 300 et seq.) describes the criteria for judging the necessity and type of remedial actions at a site [40 CFR Part 300.68(e)]. These criteria generally involve the determination of the extent to which substances on-site or off-site endanger public health, welfare, or the environment. Remedial investigations [40 CFR Part 300.68(f)] are undertaken to obtain the necessary data for the evaluation of the criteria and the subsequent evaluation of remedial action alternatives. This chapter outlines the process for determining the type and extent of remedial investigations.

Scoping a remedial investigation involves the analysis of existing data; this sets the basis for developing a sampling plan based on specific data needs. These data may be regional, such as published information on geology and soils, or site-specific if field investigations have been conducted. Generally, these data will include preliminary assessment and site inspection reports or their equivalent. The information is used to evaluate potential impacts on the public health, welfare, and the environment and to eliminate, if possible, response actions that are not appropriate to the site.

After this analysis, the remedial investigation activities necessary to collect the missing data are identified. The goal is to provide whatever additional information is necessary so that the potential impacts on public health, welfare, and the environment can be evaluated and remedial alternatives can be developed and selected. Additional data may be necessary to satisfy requirements of sites designated for enforcement. The scope, costs, and schedule of the remedial investigation are prepared and presented in the Remedial Investigation Sampling Plan.

2.2 EXISTING DATA COLLECTION AND EVALUATION

The primary objectives of data collection and evaluation are to summarize existing information on hazardous waste sources, pathways, and receptors, and to evaluate potential impacts on public health, welfare, and the environment. Analytical data from field investigations at the site, as well as information of a regional nature, are considered in this section.

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2.2.1 Collection of Existing Data

Existing information on hazardous waste sources, migration pathways, and human and environmental receptors is available from many sources; some of the more useful sources are summarized in Table 2-1. Much site information is often gathered in the National Priorities List (NPL) ranking process and may be found in EPA, field investigation team (FIT), technical assistance team (TAT), contractor, and State files. Files from site investigations, removal, or clean-up actions conducted by EPA's Emergency Response Program, for example, may contain useful historical, sampling, or cost data, especially if EPA conducted a Superfund removal at the site.

The initial step in data collection is to compile a site description, history, and chronology of significant events. These are important organizational tools in the collection of data on hazardous waste sources, migration pathways, and potential receptors. The site description should include location, size, ownership, physiographic province, topography, geologic history, and other pertinent details. Historical events of concern include site visits, disposal practices, sampling events, legal actions, regulatory violations, and changes in ownership. Also, information concerning previous clean-up actions, such as removal of waste drums, is valuable for determining the characteristics of wastes remaining at the site.

The site description uses only existing information. Gaps or insufficiency of existing data are noted, but the site description process focuses on summarizing existing data and analyses and not on the development of data to complete the description. Table 2-2 lists site and waste characteristics that may be important in the site description and the evaluation of problems and potential impacts.

2.2.1.1 Hazardous Waste Sources

The varieties and quantities of hazardous wastes disposed at the site should be investigated. The results from any sampling episodes should be summarized in terms of physical and chemical characteristics, contaminants identified, and concentrations present. If available, information on the precision and accuracy of the data should be included.

Records of disposal practices and operating procedures at the site can be reviewed to identify locations of waste materials on-site, waste haulers, and waste generators. Where specific waste records are absent, waste products that may have been disposed at the site can be identified through a review of the manufacturing processes of the waste generators.

TABLE 2-1. DATA COLLECTION INFORMATION SOURCES

Information Source	Hazardous Waste Sources	Migration Pathways			Receptors
		Subsurface	Surface	Air	
U.S. EPA Files	X	X	X	X	X
U.S. Geological Survey		X	X		
U.S. DOA - Soil Conservation Service[a]		X	X		
U.S. DOA - Agricultural Stabilization and Conservation Service		X	X		
U.S. DOA - Forest Service			X		X
U.S. DOI - Fish and Wildlife Agencies					X
U.S. DOI - Bureau of Reclamation	X	X	X		
U.S. Army Corps of Engineers	X				
Federal Emergency Management Agency[b]			X		
U.S. Census Bureau					X
National Oceanic and Atmospheric Admin.				X	
State Environmental Protection or Public Health Agencies	X	X	X	X	X
State Geological Survey		X	X		
State Fish and Wildlife Agencies					X
Local Planning Boards		X	X	X	X
County or City Health Departments	X	X	X	X	X
Town Engineer or Town Hall	X				X
Local Chamber of Commerce	X				X
Local Airport				X	
Local Library		X			X
Local Well Drillers		X			
Regional Geologic and Hydrologic Publications		X	X		
Court Records of Legal Action	X				
Department of Justice Files	X				
State Attorney General Files	X				
Facility Records	X				
Facility Owners and Employees[c]	X	X			X
Citizens Residing Near Site[c]	X	X	X	X	X
Waste Haulers and Generators[c]	X				
Site Visit Reports	X		X	X	X
Photographs	X		X		X
Preliminary Assessment Report	X	X	X	X	X
Field Investigation Analytical Data	X	X	X	X	
FIT/TAT Reports	X	X	X	X	X
Site Inspection Report	X	X	X	X	X

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[a] U.S. DOA Soil Conservation Service County Soil Survey Reports are very useful.

[b] The Federal Emergency Management Agency publishes floodplain maps.

[c] Interviews require EPA concurrence.

TABLE 2-2. SITE AND WASTE CHARACTERISTICS

SITE CHARACTERISTICS

- Site Volume
- Site Area
- Site Configuration
- Disposal Methods
- Climate
  - Precipitation
  - Temperature
  - Evaporation
- Soil Texture and Permeability
- Soil Moisture
- Slope
- Drainage
- Vegetation
- Depth to Bedrock
- Depth to Aquicludes
- Degree of Contamination
- Direction and Rate of Ground-water Flow
- Receptors
- Distance to:
  - Drinking Water Wells
  - Surface Water
  - Ecological Areas
- Existing Land Use
- Depth to Ground Water or to Plume

WASTE CHARACTERISTICS

- Quantity
- Chemical Composition
- Carcinogenicity
- Toxicity - Chronic and Acute
- Persistence
- Biodegradability
- Radioactivity
- Ignitability
- Reactivity/Corrosiveness
- Treatability
- Infectiousness
- Solubility
- Volatility
- Density
- Partition Coefficient
- Safe Levels in the Environment
- Compatibility with Other Chemicals

Source: U.S. EPA, 1985a

2.2.1.2 Migration Pathways

A summary of existing site-specific and regional information should be compiled to identify subsurface, surface, atmospheric, and possibly biotic migration pathways. Information of concern includes geology, pedology, hydrogeology, hydrology, meteorology, and air, water, and biology inventories.

Regional information will help identify background soil, water, and air quality. Results of environmental sampling at the site should be summarized in this section. Evidence of soil, water, air, or biotic contamination should be documented, and national and State standards or criteria should be referenced.

2.2.1.3 Receptors

Data on human and environmental receptors (e.g., plants and animals) in the area surrounding the site should be compiled in this section. Demographic and land use information such as whether the area is used for agricultural, industrial, commercial, or residential purposes will help identify potential human receptors. Residential, municipal, or industrial wells should be located. Surface water uses should be identified for areas surrounding and downstream of the site.

The ecology of the site should be described and the common flora and fauna of the area identified. Any threatened, endangered, or rare species in the area as well as sensitive environmental areas should be identified. Results from biological testing should be included, if available, to document bioaccumulation in the food chain.

2.2.2 Evaluation of Potential Impacts

The potential effects of hazardous substances at the site are evaluated relative to the danger they pose to public health, welfare, or the environment. Impacts should be evaluated in terms of contaminant source, migration pathways, and receptors.

Valuable resources in determining the potential impacts of chemical contaminants include the following sources:

- Registry of Toxic Effects of Chemical Substances (NIOSH, 1980)
- Dangerous Properties of Hazardous Materials (Sax, 1984)
- Handbook of Environmental Data on Organic Chemicals (Verschueren, 1977)

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- Water-Related Environmental Fate of 129 Priority Pollutants (U.S. EPA, 1979a)
- Hazardous Chemicals Data Book (Weiss, 1980)
- The Merck Index (Windholz, 1976)
- Chemical Information Resources Handbook (U.S. EPA, 1980d)
- Office of Toxic Substances (OTS) Information Architecture Notebook (U.S. EPA, 1983e).

These references are cited in the bibliography to this guidance. Additional sources include:

- EPA Chemical Activities Status Reports (series, contact Office of Pesticides and Toxic Substances' Library)
- EPA water quality criteria documents (series, contact Criteria and Standards Division, Office of Water Regulations and Standards).

2.3 DETERMINING THE NEED FOR REMOVALS OR INITIAL REMEDIAL MEASURES

Remedial actions, as defined by the NCP in section 300.68(a), "...are those responses to releases on the National Priorities List that are consistent with a permanent remedy to prevent or mitigate the migration of a release of hazardous substances into the environment."

Immediate removals, planned removals, and Initial Remedial Measures (IRMs) are remedial actions taken at a site before final selection of appropriate remedial actions. The intent of these actions is to protect the public health or the environment during the stages of remedial investigations, feasibility study, and remedial action design and construction.

Immediate removal actions, defined under section 300.65 of the NCP[1], may be considered appropriate in cases where "the lead agency determines that the initiation of [an] immediate removal action will prevent or mitigate immediate and significant risk of harm to human life or health or to the environment in such situations as:

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[1] Proposed revisions to the NCP (February 12, 1985) include changes in removal authority. The user should consult with EPA officials to determine the appropriate factors to consider when evaluating the need for a removal action.

(1) Human, animal, or food chain exposure to acutely toxic substances;

(2) Contamination of a drinking water supply;

(3) Fire and/or explosion; or

(4) Similarly acute situations."

Once an immediate removal action is determined to be appropriate, actions "begin as soon as possible to prevent or mitigate danger to the public health, welfare, or the environment. Actions may include, but are not limited to:

(1) Collecting and analyzing samples to determine the source and dispersion of the hazardous substance and documenting these samples for possible evidentiary use.

(2) Providing alternative water supplies.

(3) Installing security fencing or other measures to limit access.

(4) Controlling the source of release.

(5) MeMeasuring and sampling.

(6) Moving hazardous substances off-site for storage, destruction, treatment, or disposal provided that the substances are moved to a facility that is in compliance with Subtitle C of the Solid Waste Disposal Act. . . .

(7) Placing physical barriers to deter the spread of the release.

(8) Controlling the water discharge from an upstream impoundment.

(9) Recommending to appropriate authorities the evacuation of threatened individuals.

(10) Using chemicals and other materials in accordance with Subpart H to restrain the spread of the substance and to mitigate its effects.

(11) Executing damage control or operations." [NCP section 300.65(b)]

Specific criteria regarding immediate removals and their implementation are addressed in section 300.65 of the NCP.

Planned removals may also be implemented[2]. These removals may be done where continuation of an immediate removal would result in substantial cost savings, or where the public and/or environment is "at risk from exposure to

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[2] Ibid.

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hazardous substances if response is delayed at a release not on the National Priorities List" [section 300.67(a)(2) of the NCP]. Planned removals must be requested by the affected State (via the Governor or his designee).

Factors used to determine the need for a planned removal (as listed under section 300.67(c) of the NCP) are:

- "Actual or potential direct contact with hazardous substances by nearby population;
- Contaminated drinking water at the tap;
- Hazardous substances in drums, barrels, tanks, or other bulk storage containers, that are known to pose a serious threat to public health or the environment;
- Highly contaminated soils largely at or near surface, posing a serious threat to public health or the environment;
- Serious threat of fire or explosion; or
- Weather conditions that may cause substances to migrate and pose a serious threat to public health or the environment."

Criteria regarding the need for planned removals and their implementation are addressed further in section 300.67 of the NCP.

Initial remedial measures are implemented where "such measures are determined to be feasible and necessary to limit exposure or threat of exposure to a significant health or environmental hazard and if such measures are cost-effective."[3]

Seven factors are listed in section 300.68(e)[1](i-vii) of the NCP for determining whether IRMs are appropriate:

- "Actual/potential direct contact between hazardous substances and nearby populations. (Measures might include fences and other security precautions.)
- Absence of an effective drainage control system (with an emphasis on run-on control). (Measures might include drainage ditches.)

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[3] Proposed revisions to the NCP (February 12, 1985) include changes in remediation authority. The user should consult with EPA officials to determine the appropriate factors to consider when evaluating the need for initial remedial measures.

- Contaminated drinking water at the tap. (Measures might include the temporary provision of an alternative water supply.)

- Hazardous substances in drums, barrels, tanks, or other bulk storage containers above surface, posing a serious threat to public health or the environment. (Measures might include transport of drums off-site.)

- Highly contaminated soils largely at or near the surface, posing a serious threat to public health or the environment. (Measures might include temporary capping or removal of highly contaminated soils from drainage areas.)

- Serious threat of fire or explosion or other serious threat to public health or the environment. (Measures might include security or drum removal.)

- Weather conditions that may cause substances to migrate and to pose a serious threat to public health or the environment. (Measures might include stabilization of berms, dikes, or impoundments.)"

A limited feasibility study is performed when more than one remedial measure is considered technically viable for the immediate control of a threat. The costs of alternative initial remedial actions must be estimated and the ability of each alternative to minimize the threat to public health, welfare, or the environment must be analyzed. Existing site information is usually all that is required for such an analysis, but occasionally limited sampling is performed. The most cost-effective alternative is then recommended. A report summarizing the development and analysis of alternatives, cost estimates, selection of the most cost-effective alternative, and a schedule for implementation is submitted to the EPA. This report is similar in format and content to a full feasibility study although less detailed; a more detailed study methodology is presented in the Guidance Document for Feasibility Studies Under CERCLA (U.S. EPA, 1985a).

2.4 DEVELOPMENT OF GENERAL RESPONSE ACTIONS

General response actions are developed during scoping so that the data necessary for developing and evaluating corresponding alternative remedial actions in the feasibility study can be identified. General response actions address all the potential impacts identified in section 2.2.2. The identification of general response actions will eliminate obviously inappropriate actions, thus focusing the effort to collect data and develop remedial action alternatives. The Guidance Document for Feasibility Studies Under CERCLA (U.S. EPA, 1985a) and the Manual on the Selection and Evaluation of Remedial Responses (U.S. EPA, 1984d) provide specific guidance for identifying general response actions and explain the role of this process in the feasibility study.

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2.5 DATA NEEDS

Remedial investigations must obtain sufficient data to allow a feasibility study of remedial action alternatives. The NCP recognizes in section 300.68(i)(3)[4] that: "[I]n performing the detailed analysis of alternatives, it may be necessary to gather additional data in order to complete the analysis." In the remedial investigation, it is not necessary to determine all the site and waste characteristics for every site. The information on site and waste characteristics that must be obtained depend on the information required to:

- Assess alternatives (including the no-action alternative) during the feasibility study
- Support enforcement or cost recovery procedures
- Conduct health assessments or special studies.

2.5.1 Data Limitations in the Assessment of Potential Impacts

The evaluation of existing data will identify what remains to be clarified about the types and extent of contamination, pathways of contaminant migration, and receptors. The limitations identified in the data should be compiled under each of the data evaluation subheadings:

- Hazardous waste sources, including location, quantities, concentrations, and characteristics
- Migration pathways, including information on geology, pedology, hydrogeology, physiography, hydrology, water quality, meteorology, and air quality
- Receptors, including demography, land use, and ecology
- Engineering aspects, including soils, etc.

The most important criterion in determining if the information within a particular category is sufficient is that the data must be complete enough to allow the RI/FS team to evaluate fully the need for source control or management of migration measures and the alternatives for meeting these needs.

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[4] Federal Register, Vol. 47, No. 137, July 16, 1982.

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2.5.2 Data Limitations in the Assessment of Remedial Actions

While the remedial investigation is still going on, initial data collected from field efforts will be used to analyze the feasibility of remedial alternatives. During the analysis of remedial alternatives for the feasibility study, data gaps may be identified which require that additional information be collected during the site characterization. In other words, the remedial investigation and feasibility study activities overlap as specific data needs are identified during the development, screening, and evaluation of alternatives. It is essential that these data needs be communicated to the remedial investigation team. The more effective the user is in communicating data needs from the feasibility study to the remedial investigation, the more efficient the site characterization process will be. In addition, the information collected will be more valuable if it is focused on resolving issues that will determine the adequacy and design characteristics of the remedial alternatives being analyzed.

CHAPTER 3

SAMPLING PLAN DEVELOPMENT

3.1 INTRODUCTION

The sampling plan defines the level of effort and specific field activities for a remedial investigation. The objectives of a sampling plan are to:

- Provide specific guidance for all field work
- Provide a mechanism for planning and approving site activities
- Provide a basis for estimating costs of field efforts
- Ensure that sampling activities are limited to those that are necessary and sufficient
- Provide a common point of reference for all parties to ensure comparability and compatibility between all activities performed at the site.

A sampling plan should be prepared for any site investigation that includes field work.

While the basis of a sampling plan is the existing site information, additional information needs may be identified during scoping (chapter 2) or from technical, environmental, and health information needs identified during feasibility studies. During the remedial investigation, or a concurrent feasibility study, it may be necessary to revise the sampling plan to increase the detail of information collected or to focus efforts on a particular problem. Before development of a sampling plan, the validity of available data should be assessed, and the value of additional data should be determined. Only those data that are necessary and sufficient to meet the objectives of each investigation should be proposed for collection.

Sampling plans are normally developed by the contractor's Site Project Manager for review and approval by the Remedial Site Project Officer. The Regional Director, the EPA Office of Emergency and Remedial Response, and other cognizant State and Federal agencies may also review the plan, as directed by the Remedial Site Project Officer. The approved sampling plan may also be reviewed by the potentially responsible parties. Because elements of the sampling plan are directly related to the site-specific quality assurance plan, the Regional Quality Assurance Office must participate in the review.

The sampling plan must incorporate data needs for enforcement, or any health-study-related objectives. Where enforcement activities are involved, the plan should be reviewed by the Office of Waste Programs Enforcement or regional enforcement personnel. Where health studies are involved, the plan should be reviewed by the responsible health agency.

Because sites vary greatly in size and complexity, it is not possible to develop general quantitative guidelines. The guidance in this document focuses on considerations during plan development. Section 3.2 contains a general discussion of the elements that constitute an acceptable sampling plan. Factors of a programmatic or procedural nature that should be considered during preparation of a plan are presented in section 3.3. Sections 3.4 and 3.5 discuss general procedures for sampling and data collection, with reference to more specific information. Finally, section 3.6 provides guidance on estimating the efforts required during sampling plan development.

3.2 ELEMENTS OF THE SAMPLING PLAN

The sampling plan should, at a minimum, discuss the following:

- Investigation objectives
- Site background
- Analysis of existing data
- Analytes of interest
- Sample types
- Map of locations to be sampled
- Sample locations and frequency
- Analytical procedures
- Operational plan/schedule
- Cost estimate.

The sampling plan should also refer to other relevant documentation, data management, quality assurance/quality control, and health and safety procedures identified in the respective project plans (see chapters 4 and 5).

3.2.1 Objectives

The investigator should clearly state the specific objectives of a sampling effort. These objectives will be developed within the framework of the overall remedial investigation.

The sampling plan objectives state the precise reasons for the sampling effort, with respect to the ultimate use of the data. The objectives will be determined by the detail required at a site. The data needs identified by scoping activities may focus sampling activities on specific subareas, matrices, or contaminants of interest. Any limitations in focus should be identified and presented in the plan.

3.2.2 Background

The site background description will be based on data collected during scoping activities (chapter 2). Background information should consist of the following information:

- A description of the site and surrounding area will be referenced, noting any conditions that may affect the sampling effort. This includes any limitations in conducting field activities, such as extreme weather or difficult terrain.
- A discussion of known and suspected contamination sources will be referenced, listing probable transport pathways and impacts. Expected concentrations of contamination should be noted.
- Sources of information about the site should be referenced. Information sources may include visual observations, files of the waste generator or facility owner, files of local or State authorities, geological and meteorological records, and the project files dealing with site characterization.
- Any observed or reported environmental impacts in the vicinity of the site or along the probable transport pathways should be referenced.
- Any specific data gaps should be noted, and the approach that is being taken to fill these gaps should be discussed.

3.2.3 Evaluation of Existing Data

Analysis and evaluation of data collected in accordance with an approved sampling plan are essential site characterization activities. However, it may also be necessary to evaluate existing data before sampling begins in order to develop an effective sampling plan. Statistical analysis can show the need for additional data by examining the validity, sufficiency, and relevancy of existing data. Additional sampling locations can be included in the analysis to determine how they would affect the accuracy of the site characterization. In this way, statistical techniques can be used to determine the optimum sampling locations, thereby minimizing the number of new sampling points required. The results of these analyses should be included in the sampling plan.

3.2.3.1 Determining Data Validity

Because the remedial investigation/feasibility study decision process depends on data collected at the site, quantitative evaluation of the validity of the data is essential. Validation analyses should be performed on all existing data before the sampling plan is developed to ensure that errors are identified and any necessary resampling is scheduled.

Before existing data are used, the data and supporting documentation should be evaluated. This evaluation should be similar to a quality assurance audit. Data may be considered invalid if the following information is not available:

- Sampling date
- Identity of sampling teams or person in charge
- Sampling location and description
- Sampling depth increment
- Collection technique
- Field preparation technique
- Laboratory preparation technique
- Laboratory analytical methods
- Laboratory detection limits.

Data validity may also be checked using statistical cross-validation procedures (Devary and Hughes, 1984). These procedures involve predicting a data value for one member of the population from the remaining members of the population. The difference between the measured and predicted data value, when compared with the prediction uncertainty, may suggest an invalid data point or an inaccurate conceptualization of the phenomenon being studied. For example, a measured surface-water flow rate considerably higher than predicted or indicated by data trends could suggest an erroneous data value, or perhaps could be the result of an as yet unidentified phenomenon.

3.2.3.2 Determining Data Sufficiency

Determining data sufficiency means answering the question, "Do the existing data adequately characterize the site?" This determination entails defining the number of samples of each matrix that are necessary and sufficient to satisfy the sampling objectives. Statistically, data sufficiency involves determining whether confidence levels for measured or predicted values are rigorous enough to satisfy regulatory and engineering criteria. For example, it might be mandated that the ground-water contaminant concentration near a water supply will be below EPA drinking water standards with a specified certainty. Various statistical methods can be used to plan sampling that will efficiently meet this certainty requirement. Similarly, the sensitivity analysis may suggest that no additional sampling is required, i.e., the added data will not significantly reduce uncertainty. The sampling plan should discuss both such analyses.

Statistical methods alone, however, may not be able to address all aspects of data sufficiency; for example, when statistical analyses indicate the need for an unreasonable number of samples, scientific insight into the phenomenon being studied may allow reductions. Best engineering judgment should be considered along with statistical accuracy in determining the sufficiency of site characterization activities. These judgments should be documented and summarized in the sampling plan.

3.2.3.3 Determining Data Sensitivity

During the initial phase of data evaluation, sensitivity studies may be performed to determine the impact on site assessment if additional sampling is not performed. Methods are available that may be used to calculate the range of probable values at nonsampled locations and to determine the effect of this uncertainty on site assessment; one example of such methods is the kriging technique of conditional simulation for ground water (Journal and Huijbregts, 1978). Sensitivity studies also permit the evaluation of sampling plans without actual performance of the sampling.

3.2.4 Determination of Chemical Contaminants of Interest

Specification of the hazardous substances to be considered at a site is essential to scoping the sampling and analysis program. The sampling plan should contain a list of the parameters for which data are needed. The waste constituents that are known to be, or are likely to be, found at each site (or at each major source within a site) and in surrounding environmental media should be identified. These may be identified from site data defining source characteristics including records identifying wastes deposited, site history, site operations (e.g., chemical manufacturing, metal finishing), generators of wastes deposited at the site (e.g., likely producing processes), etc. If information on source characteristics is insufficient to identify analytes of

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interest, candidates can be selected from the list of hazardous substances as defined in the Comprehensive Environmental Response, Compensation, and Liability Act, sections 101(14) and 104(a)(2). Field screening methods may also be appropriate to determine the contaminants of interest. Although cost is important, it is not advisable to limit the analytical parameters if data sources are inadequate.

If only specific analytical parameters are selected, a site characterization bias may be introduced. Sampling for only the selected parameters may then result in incomplete site characterization. A trade-off analysis should be performed of the uncertainties introduced by biased sampling and analysis versus the need to limit sampling and analysis efforts to those that are necessary and sufficient. The objectives of the remedial investigation for which the sampling effort is being planned are the basis for this trade-off analysis.

3.2.5 Determination of Sample Types

The environmental matrices to be sampled depend on the characteristics of the source and the site environment, as well as the purpose of the investigation. The appropriateness of biased or unbiased sampling will aid in selecting the matrix of interest. The matrices chosen for biased sampling would be those most likely to provide positive evidence of hazardous materials, probably at high concentrations. Unbiased sampling would include matrices from all migration routes to a thoroughly characterized contaminant distribution.

The sampling plan should identify the number of each sample type to be collected, describe collection methods, specify each sampling location, and give a brief rationale for the selection of the location. (Selection is discussed in section 3.2.6.) Because some analyses can be performed in the field, the plan should differentiate between those that will be conducted on-site and those that will be sent to a laboratory.

The objectives of the remedial investigation determine the types of samples to be collected. Ground-water and surface-water problems require many data items including source strengths, disposal practices (release times and durations), water contamination concentrations, precipitation/infiltration rates, and aquifer characteristics. Air deposition problems require such data as source strengths, disposal practices (release times and duration), soil contamination levels, as well as meteorological information collected over sufficiently long time periods. Occasionally, receptor sampling is necessary to define the effects of a hazardous waste site on the susceptible environment. Further, modeling studies may have information requirements different from those for establishing contaminant levels.

Samples are generally of the following types:

- Samples to characterize the source. Characterization of the source may require extensive sampling if transport modeling for remedial actions, source control measures, or removal operations are being considered.

- Samples to characterize transport pathways. Evaluation of the transport of hazardous substances from source to receptor may require extensive air, surface-water, ground-water, soil, and sediment sampling.

- Samples to define receptor impacts and effects. Assessments of exposure or endangerment may require collection of flora and fauna as receptor organisms. The major drawback of receptor studies is the large uncertainty associated with uptake and dose mechanisms; cause and effect is very difficult to prove with any certainty. The basic statistical mechanism for comparing differences between receptor test and control (or background) populations is the modified Student's t-test for unequal variances (Snedecor and Cochran, 1980).

- Samples to conduct modeling studies. Successful use of environmental models may require media-specific studies of air, surface water, ground water, soil, or sediments.

3.2.6 Determination of Sampling Locations and Frequency

The parameters of a sampling program include the types, locations, and frequency of sampling. These parameters are site-specific. Sampling locations should be specified in the plan, preferably both in tables and on maps, which should be based on aerial photography. Each sample location should also be justified. Information in Ford, Turina and Seely (1983) provides guidance on scoping a sampling plan.

The general criteria for sample location are: (1) enough samples should be taken to delineate the source, the spatial extent of contamination, actual (or potential) pathways through the environment, the impact on susceptible receptors, and to support anticipated modeling needs, and (2) the number of samples should be minimized according to the "necessary and sufficient" philosophy while still meeting the objectives of the investigation. The sampling plan should clearly state levels of confidence within which data will be considered accurate. These levels are determined in part by the objectives of the study and by guidelines contained in the quality assurance plan.

The frequency of sampling depends on the site environment and the most probable pathways for transport. Pathways or receptors affected by seasonal variations or weather patterns may require multiple sampling. Examples of multiple sampling areas include crop sampling over a growing season and surface-water sampling through seasonal variations. Hourly sampling may be required to evaluate environmental variations in tidally influenced areas.

3.2.7 Preparation for Sampling

Adequate preparation for a field sampling trip is extremely important and should be specified in the sampling plan. The EPA's National Contract Laboratory Program (CLP) or other qualified laboratories may conduct sample analysis for Federal-lead projects. State or private parties must generally procure qualified laboratories for sample analysis. The following elements can affect field operations, safety, sample validity, and analytical results:

- Coordination with analytical laboratories. For Federal-lead sites, coordination with the CLP Sample Management Office or with the laboratory that will conduct the analyses should begin during sampling plan preparation. Limitations on sampling due to laboratory capacity or special sample requirements may require scheduling or sample collection modifications. Further, the analytical capabilities of the laboratory should also be ascertained to enable selection of the appropriate laboratory; for example, certain analytical techniques such as gas chromatography (GC) or mass spectrometry (MS) may not be available from CLP laboratories. The Sample Management Office will require information on analytes, matrices, number of samples, approximate concentrations, and when samples will start to arrive. The name and shipping address of the laboratory to be used will be provided by the Sample Management Office. Analytical laboratories should be provided with the same information requested by the Sample Management Office for actions carried out by States or responsible parties. Similarly, these requirements should also be met where non-CLP laboratories are used in Federal-lead projects.

- Sample containers. Containers will be obtained from the Sample Management Office. For responsible party actions or non-CLP laboratories, the laboratory should provide containers that have been cleaned according to U.S. EPA procedures. Sufficient lead time should be allowed. Container specifications will depend on the analyte and sample matrix types. Shipping containers for samples, consisting of sturdy ice chests with locks, are provided by the remedial investigation contractors.

- Equipment. All equipment should be checked for serviceability prior to packing. Before packing, the mode of shipment should be selected and necessary arrangements made. Motor freight will handle some things that air freight will not; also, motor freight is less expensive but takes longer.

- On-site analytical equipment. All instrumentation for use on-site should be checked and calibrated before and after shipping. Appropriate standards, solvents, glassware, and cleaning materials should be shipped or acquired. If a mobile laboratory is to be used on-site, schedules and other arrangements should be made.

- Protective clothing, safety equipment. Protective clothing and safety equipment should be checked for serviceability before packing. Duplication of necessary equipment and spare parts is essential. Sufficient quantities should be packed to meet changing needs as well as to replace damaged items.

- Record-keeping. Necessary labels, shipping forms, chain-of-custody forms, etc., should be ordered from the Sample Management Office or from the laboratory. Plenty of lead time should be allowed.

- Cleaning materials. Distilled water, paper towels, etc., may be purchased locally. A sample of the distilled water can be sent to the lab for analysis as a field blank.

- Preservation materials. Preservatives should be available in ample quantities for the required number and type of samples.

- Packing materials. Vermiculite, paint cans, plastic bags, tape, and shipping labels should be available for the numbers of samples and shipping containers expected.

3.2.7.1 Development of Operational Plans for Sampling

Clearly specified responsibilities and procedures contribute to cost-effective and safe field sampling. A sampling logistics plan should contain the following elements:

- Team members. Team members should be chosen and notified as far in advance as possible to ensure availability of the required expertise. The team leader and other team members should have input to the sampling plan. Each team member should be trained in field procedures and equipment operation, especially if new techniques or special procedures will be used.

- Documentation. Evidentiary (chain-of-custody) requirements demand extensive paperwork and documentation. All paperwork (sample sheets, labels, shipping forms, log books, etc.) should be identified in the sampling plan, and forms obtained well before the trip. (See U.S. EPA, 1982b, for more information.) Sampling team members should be familiar with the required documentation before they go in the field.

- Equipment. A list of equipment required in the field and a set of procedures for using the equipment should be provided. All equipment should be tested and checked for operability and safety before field use.

- Sampling order. Using a map of sample locations and type of samples, an "operations" plan should be devised to use team members most effectively in the field.

- Decontamination. Specific decontamination procedures and equipment should be specified, chosen, and obtained prior to the trip. Disposal of decontaminated clothing, solutions, etc., should be arranged in advance. Disposal permits or clearance of procedures by State agencies may be necessary.

3.2.7.2 Summary of Guidance on Weights and Volumes of Equipment and Supplies

Typical sampling efforts need large volumes and heavy weights of equipment and supplies. Therefore, planners of investigation activities must consider the time required for shipping and shipping costs. Good planning ensures timely delivery of materials at the site. Costs should be minimized within the time constraints imposed by material availability and site needs. All shipping should conform to Department of Transportation regulations (40 CFR 172).

Field activity planning must also consider shipment of samples to the laboratory. Many samples have limited holding times after which analytical results are suspect. Therefore, the method of shipment will be determined based on applicable holding times. Such arrangements should be made in advance of field activities to prevent delays in the field. The analytical laboratory may be able to provide guidance on applicable and reliable shipment methods.

3.3 FACTORS TO CONSIDER IN A SAMPLING PLAN

The sampling plan should consider the requirements for documentation, efficiency, and safety. The degree to which these aspects are addressed in the sampling plan varies from site to site. At a minimum, record-keeping, quality assurance/quality control, health and safety, personnel requirements, and decontamination/disposal apply to all sites.

3.3.1 Record-keeping

Because all data and means of data collection may be used for evidence, a rigid system is needed for data and activity documentation and record-keeping. The EPA Contract Laboratory Program has established standard operating procedures for sampling documentation. The following documents, forms, labels, and other records have been found useful by CLP and should be specified in the sampling plan:

- Organic traffic reports (Field Sample Record and Transmittal/Submission form for samples for organic analyses)

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- Inorganic traffic reports (Field Sample Record and Transmittal/Submission form for samples for inorganic analyses)
- High-hazard traffic reports (Field Sample Record and Transmittal/Submission form for any sample suspected of containing at least 15 percent contamination)
- Sample tags/custody seals
- Chain-of-custody forms
- Field log books
- Other special logs and/or forms.

The sampling plan should allow adequate time and labor for handling the paperwork associated with field exercises. For large sampling efforts, one full-time member per sampling team is necessary; for smaller efforts, about a 20 to 25 percent increase in sampling time should be allowed for documentation.

3.3.2 Related Management Plans

The sampling plan should include sampling quality assurance and health and safety plans. These plans are part of the overall and site-specific quality assurance and health and safety programs described in chapters 4 and 5, respectively.

3.3.3 Specification of Sampling Personnel

As a rule, sampling and other field work should be conducted by experienced personnel who are, at a minimum:

- Thoroughly familiar with field sampling procedures, protocols, and ancillary requirements
- Involved in a health and safety monitoring program (including appropriate training)
- Able to work as part of an organized team
- Available for the entire sampling trip.

The following sampling team functions, major criteria, duties, and responsibilities will normally be specified within a sampling plan:

- Team Leader. Performs background research; selects team; prepares sampling operational plan; briefs team; handles on-site public affairs; accepts and releases samples and paperwork; generates deliverables and reports
- Equipment Officer. Collects, checks, packs, ships all equipment and supplies; calibrates instruments; provides supplies and spare parts; is responsible for air tanks, decontamination, sample containers
- Site Safety Officer. Prepares safety plan; briefs and trains team; oversees decontamination; oversees health aspects of work; performs emergency procedures
- Record Custodian. Maintains field notebooks, logs, sample labels, and custody forms; oversees sample packing and shipping
- Work Party (as necessary). Works within the controlled access zone under the direct observation of one or more of the team principals.

Individual team members may perform several of these functions, especially at small sites. However, for safety reasons, the minimum team size is three: one person outside the controlled-access zone and at least two people within the zone operating according to the "buddy system."

3.3.4 Decontamination and Disposal

Almost all on-site activities require some type of protection/decontamination procedures for personnel and equipment. The sampling plan should address at least the following:

- Decontamination equipment should be ready to use before site entry. Decontamination solutions should be specified if the type of contamination is known.
- Equipment should be decontaminated after each sample to avoid cross-contamination.
- Contaminated equipment, clothing, and decontamination solutions should be disposed of on-site. If this is unacceptable, alternative disposal should be arranged before work starts.

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3.4 SPECIFICATION OF SAMPLING PROCEDURES

A complete protocol and step-by-step procedure for each field exercise or sample collection will be included in the sampling plan. Generally, sampling may involve any or all of the following matrices:

1. Source Sampling
    - Drums and tanks
    - Impoundments, lagoons, and seeps
    - Solid waste
    - Highly contaminated media near sources.
2. Ground-Water Sampling
    - Monitoring wells
    - Production wells
    - Domestic supplies.
3. Surface-Water Sampling
    - Ponds and lakes
    - Streams
    - Runoff and springs.
4. Soil and Sediment Sampling
    - Bottom sediments
    - Grab samples
    - Core samples
    - Samples for physical measurements.
5. Air Sampling
    - Monitoring stations
    - Point samples
    - Composite collection samples.

6. Biological Sampling

- Flora samples
- Fauna samples.

For complete descriptions of methods and procedures, the user is referred to U.S. EPA (1982b,c), American Public Health Association (1980); Ford, Turina, and Seely (1983); Mason (1983); U.S. EPA (1971), and American Society for Testing Materials (1974).

3.5 DATA ACCEPTABILITY AND UTILITY

The design of sampling plans should ensure that data will be acceptable and usable. Statistical analyses similar to those used to evaluate existing data (section 3.2.3) should ultimately be applied to the results of the remedial investigation site characterization effort. Recognizing this, the investigator should review the sampling plan to ensure that it considers statistical uses and quality control/quality assurance.

3.6 ESTIMATING EFFORTS REQUIRED FOR SAMPLING PLAN DEVELOPMENT

The general organization and key elements of the sampling plan are discussed in sections 3.2 and 3.3. The personnel and expertise required to prepare each of these elements of the sampling plan are summarized in Table 3-1 and discussed below.

- Background. Site background information may require input from several technical disciplines, depending on the problems at the site and the level of detail of existing information. Personnel trained in geology, hydrology, meteorology, environmental chemistry, and biology should be able to discuss existing conditions, sources, pathways, and effects.

- Evaluation of existing data. Staff members with backgrounds in statistics and geostatistics should be able to discuss data validity, relevancy, and sufficiency. An analysis of the effect on assessments and subsequent site investigation may also require inputs from geologists, chemists, or environmental engineers, depending on site conditions.

- Determination of analytes of interest. Staff members with expertise in environmental chemistry, analytical chemistry, and toxicology should identify analytes of interest and describe preservation, handling, containers, and methods.

TABLE 3-1. APPROPRIATE TECHNICAL DISCIPLINES FOR SAMPLING PLAN PREPARATION

Sampling Plan Element	Appropriate Discipline								
	Biology	Analytical Chemistry	Environmental Chemistry	Environmental Engineering	Geology	Hydrology	Industrial Hygiene	Meteorology	Statistics
Background	X		X		X	X		X	
Statistical Analysis of Existing Data		X	X	X	X				X
Determination of Analytes of Interest		X	X				X		
Determination of Sample Types	X			X	X	X	X		X
Determination of Sampling Location and Frequency	X			X	X	X	X		X
Preparation for Sampling Episodes				X	X		X		
Quality Assurance/Quality Control		X	X		X				X
Safety Plan							X		

- Determination of sample types. This section of the sampling plan may require inputs from a variety of technical desciplines. A discussion of biased versus unbiased sampling approaches must be prepared by a statistician or geostatistican. Discussions of particular environmental media (water, air, soil, biota) should be prepared by geologists, hydrologists, environmental engineers, or biologists, as appropriate.

- Determination of sampling locations and frequency. Statisticians/ geostatisticians, geologists, hydrologists, environmental engineers, and/or biologists will have input into this section of the sampling plan.

- Preparation for sampling episodes. Project management should prepare the programmatic aspects of this section. Procedural aspects concerning acquisition, packaging, shipment, etc., should be discussed by a senior sampling technician.

CHAPTER 4

DATA MANAGEMENT PROCEDURES

4.1 INTRODUCTION

A remedial investigation may involve many agencies, contractors, and other entities, all of which generate extensive information. This chapter outlines procedures to ensure that the quality and integrity of the data collected are maintained for a feasibility study and/or for any legal or cost recovery actions. The disposition of data during an RI, as well as any special data handling procedures, are described in this chapter.

The following discussion is divided into three sections:

- Overview of data management protocols and guidelines
- Data management requirements for specific RI tasks
- Financial and project tracking.

4.2 OVERVIEW OF DATA MANAGEMENT PROTOCOLS AND GUIDELINES

Two main types of information associated with an RI must be documented. The first type of information comprises technical data that are either required for or generated by a specific RI task such as scoping or site characterization. This information includes both field data (e.g., samples, sample tags, field log books) and data resulting from subsequent laboratory or engineering analyses (e.g., graphs or modeling results).

The second type of information consists of data that must be tracked to monitor, manage, and document the actual performance of the RI tasks. This information, called project tracking data, usually includes schedules, cost estimates, technical progress reports, and financial management reports. Table 4-1 lists examples of the technical and management documentation that are usually necessary.

Specific data management protocols and guidelines should be followed in documenting the two primary types of information. These protocols ensure that the validity of the data is safeguarded for decisions made during the feasibility study and for any future legal or administrative actions such as cost

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TABLE 4-1. EXAMPLES OF RI SUPPORT DOCUMENTATION

Field/Laboratory Documentation

- Project/Field Log Books
- Sample Tags
- Sample Data Sheets and Logs
- Chain-of-Custody Records, Seals
- Receipt of Sample Forms
- Laboratory Log Books
- Laboratory Data, Calculations, Graphs

RI Management Reports

- Draft/Final Work Plan(s)
- Health/Safety Plan
- Sampling Plan
- Quality Assurance/Quality Control Plan
- Data Management Plan
- Project Management Plan

RI Task Reports

- Site Description
- Contamination Assessment
- Environmental Assessment
- Public Health Assessment
- Endangerment Assessment
- Draft/Final RI Report

Technical Progress and Financial Reports

- Monthly Technical Progress Report
- Monthly Financial Progress Report
- Cumulative Project Cost Report

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recovery. Such protocols and guidance have been established by the EPA and include the National Enforcement Investigations Center (NEIC) Policies and Procedures Manual (U.S. EPA, 1981b) and the Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans (U.S. EPA, 1980c) which describe detailed procedures for sample identification, chain-of-custody, document control, and quality assurance. This guidance should be consulted prior to planning any RI activities or establishing RI procedures.

Although not necessarily different from other information, some data, documents, and other materials may be confidential either for business security (e.g., trade secrets) or legal reasons. These materials should be treated according to guidelines provided by case attorneys or outlined in the following publications:

- TSCA Confidential Business Information Security Manual (U.S. EPA, 1981c)
- Contractor Requirements for the Control and Security of TSCA Confidential Business Information (U.S. EPA, 1981a)
- Draft Contractor Requirements for the Control and Security of RCRA Confidential Business Information (U.S. EPA, 1984d)
- Draft RCRA Confidential Business Information Security Manual (U.S. EPA, 1984c)
- FIFRA Confidential Business Information Security Manual (U.S. EPA, 1981f).

It is difficult to estimate the level of effort required for data management, but experience has shown that 5 to 10 percent of the total effort for the RI is appropriate. Following the guidelines described in this section will minimize the generation of data that are not scientifically nor legally defensible and consequently reduce the data management effort.

This section highlights and summarizes the fundamental components of good data management practices. The components discussed include data processing and storage and quality assurance.

4.2.1 Data Processing and Storage

The two types of data associated with the RI (data required to perform a specific activity or data generated by the activity) must be accurately communicated and properly managed. Data processing and storage are essential to preserve both the results of the individual task and the inputs for other tasks still to be conducted. Moreover, the information must be carefully documented to support any future legal or administrative actions that may be taken. These actions may not occur for years after the data have been gathered. Thus, it is crucial that records be sufficiently detailed to provide a complete and accurate history of data gathering and results.

This section focuses on the precautions and essential steps to be taken in data processing and storage. The topics covered include:

- Documenting field measurements and observations
- Sample identification and chain-of-custody
- Document control, inventory, and filing systems.

These three topics provide the basis for a documentation system suitable for any RI.

4.2.1.1 Documenting Field Measurements and Observations

All field measurements and observations should be recorded in project log books, field data records, or similar types of record-keeping books. Field measurements include pH, temperature, conductivity, water flow, and certain air quality parameters. All data must be recorded directly and legibly in field log books with all entries signed and dated. If entries must be changed, the change should not obscure the original entry. The reason for the change should be stated, and the change and explanation should be signed and dated or identified at the time the change is made. Field data records should be organized into standard formats whenever possible, and retained in permanent files such as those described in section 4.2.1.3, which discusses document control, inventory tracking, and filing systems.

4.2.1.2 Sample Identification and Chain-of-Custody

Field samples should be identified by a sample tag or other appropriate labeling technique (this text refers to all such techniques as sample tags). The information on the sample tag should include: the date and time the sample was collected, the sampling location or station and cross-reference to the sampling plan, the name of the individual collecting the sample, and any pertinent remarks. Copies of the sample tags should be stored in a permanent file maintained for the site (see section 4.2.1.3).

Samples and data from samples are often used as legal evidence. Therefore, sample possession must be traceable from the time the sample is collected or developed until it and the derived data are introduced as evidence in legal proceedings. Chain-of-custody procedures should be followed to document sample possession. A sample is considered under your custody if:

- It is in your possession, or
- It is in your view, after being in your possession, or
- It is in your possession and you locked it up, or
- It is in a designated secure area.

Chain-of-custody procedures should be established for each RI and should address:

- Field custody procedures
- Transfer of custody and shipment
- Receipt of samples
- Laboratory custody procedures.

Sample identification and chain-of-custody procedures are established in the National Enforcement Investigations Center Policies and Procedures Manual (U.S. EPA, 1981b); this document should be consulted in establishing such procedures. Any documentation associated with these procedures (e.g., chain-of-custody records or receipts for sample forms) should also be placed in a permanent project file.

4.2.1.3 Document Control, Inventory, and Filing Systems

Precautions should be taken in the analysis and storage of the data collected during an RI to prevent the introduction of errors or the loss or misinterpretation of data. The data storage and information system should be capable of:

- Receiving all data
- Screening and validating data to identify and reject outliers or errors
- Preparing, sorting, and entering all data into the data storage files (either computerized or manual)

- Providing stored data points with associated quality assurance/quality control (QA/QC) "labels," which can indicate the level of confidence or quality of the data. These labels should:
  - Indicate what QA/QC activities were included in the major steps of the monitoring process
  - Quantitatively describe the precision/accuracy of the analysis
  - Make data available to users
- Assuring efficiency in data security and disclosure.

Specific requirements and procedures for these aspects of data processing will be described in the QA plan prepared for the project. A member of the project team should be designated to establish and maintain the document control system for the duration of the investigation.

The document inventory/filing systems should be based on serially numbered documents. These systems may be manual or automated. A suggested structure and sample contents of a file for Superfund activities are shown in Table 4-2. Regardless of the type of document control system used, it should be protected from intentional or accidental destruction or damage. Often in the case of enforcement actions, an attorney may designate portions of the file as "enforcement sensitive." These documents should be maintained separately.

4.2.2 Quality Assurance/Quality Control (QA/QC)

Decisions concerning the control and management of hazardous substances documented in the feasibility study or the need for legal actions are based on analytical data generated during the RI. Because such decisions can be no better than the data on which they are based, the quality of the data must be ensured. A comprehensive and well-documented QA program is essential to obtaining precise and accurate data that are scientifically and legally defensible. The concepts outlined in the QA program must be considered in decisions about the selection of sites for sampling; the frequency of sampling; the number of samples to be collected; the procedures involved in the collection, preservation, and transport of samples; the calibration and maintenance of instruments; and the processing, verification, and reporting of the data. Specific QA/QC requirements apply to several sampling and site characterization RI activities.

The objectives of sampling quality assurance are: (1) to ensure that the procedures used will not detract from the quality of results, and (2) to ensure that all activities, findings, and results follow an approved plan and are documented. These objectives dictate that much of the sampling quality

TABLE 4-2. OUTLINE OF THE FILE STRUCTURE FOR THE SUPERFUND SITES

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1. Congressional Inquiries/Hearings

- Correspondence
- Transcripts
- Testimony
- Published hearing records

2. Remedial Response

- Discovery
  - Initial investigation reports
  - Preliminary assessment report
  - Site inspection report
  - Hazardous ranking system
  - Sampling and analysis data
- Remedial Planning
  - Correspondence
  - Work plans for remedial investigation/feasibility study
  - Remedial investigation/feasibility study reports
  - Health and safety plan
  - Quality assurance/quality control plan
- Remedial Implementation
  - Remedial design reports
  - Permits
  - Contractor work plans and progress reports
  - Corps of Engineers agreements, reports, and correspondence
- State and Other Agency Coordination
  - Correspondence
  - Cooperative agreement/Superfund State contract
  - State quarterly reports
  - Status of State assurances
  - Interagency agreements
  - Memorandum of Understanding with State

(continued)

TABLE 4-2. (continued)

- Community Relations
  - Correspondence
  - Community relations plan
  - List of people to contact, e.g., local officials, civic leaders, environmental groups
  - Meeting summaries
  - Press releases
  - News clippings

3. Imagery

- Photographs
- Illustrations
- Other graphics

4. Enforcement

- Status reports
- Cross-reference to any confidential enforcement files and person to contact
- Correspondence
- Administrative orders

5. Contracts

- Site-specific contracts
- Procurement packages
- Contract status notifications
- List of contractors

6. Financial Transactions

- Cross-reference to other financial files and person to contact
- Contractor cost reports
- Audit reports

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assurance effort be made before the field work. Activities that should precede sampling include:

- Preparing written protocols for all activities
- Training all field team members to use the equipment, procedures, and documentation
- Ensuring that all containers and equipment have been properly cleaned and are appropriate for matrices and analytes of interest
- Ensuring coordination with the laboratory.

A distinction should be made between field quality control and laboratory quality control. Any laboratory analyzing samples from hazardous waste sites will have an associated quality control program (in the case of the Contractor Laboratory Program, this program is standard), and it is tempting to rely on the laboratory for all quality control. However, the laboratory's program provides adequate quality control for the analytical function only and cannot be used to ensure the quality of the entire sampling and analysis process. Consequently, the sampling plan should provide for adequate "field quality control" to permit evaluation of the validity of results.

In addition to provisions for quality control, sampling quality assurance should specify a system of quality assurance procedures, checks, audits, and corrective actions that is specific to the site activities.

The purpose of site characterization quality assurance and control is to ensure that the data collected are of known and sufficient quality to assess contamination at the site qualitatively and quantitatively. QA/QC control for site characterization encompasses two important aspects:

- Records of traceability and adherence to prescribed protocols, complete descriptions of relaxed or lax quality control, and corrective actions
- Data on the quality of the data collection and analyses, deficiencies that may affect quality, and the uncertainty limits for results.

Thus, the quality assurance/quality control plan should address at least the following elements:

- Objectives of QA/QC
- QA/QC aspects of measurements, sampling, and analytical procedures

- Calibration, preventive maintenance, and corrective maintenance procedures

- Data reduction and interpretation procedures

- Quality assurance/quality control performance audits, corrective actions, and verifications

- Documentation and document control for QA/QC

- Personnel responsible for QA/QC tasks.

Because the primary aim of the quality assurance/quality control program is to ensure that the data are reliable, rather than to ensure that a poorly conducted program is adequately documented, the QA/QC aspects of site characterization should be planned in advance as an integral part of the investigation. Factors that must be considered in this planning include an evaluation of the types of data needed, the required level of certainty, and the availability of data collection and assessment procedures that can provide the desired level of reliability cost effectively. These quality assurance/quality control factors vary according to the investigation phase. For example, the uncertainty limits demanded for data during an initial investigation (i.e., for essentially qualitative assessments) may be much broader than those required during detailed assessments. The essential point is that data limitations must be known and must be in accordance with the "necessary and sufficient" philosophy governing RI planning and activities.

4.3 DATA MANAGEMENT REQUIREMENTS FOR SPECIFIC RI TASKS

The following discussion outlines data management guidelines and procedures that apply to RI activities described in other chapters of this document. These include:

- Scoping
- Site characterization and sampling
- Health/safety programs
- Institutional issues
- Pilot- and bench-scale studies

Procedures for the disposition of data and any special data handling are presented in this section. This information is oriented toward Government-lead projects (Federal or State). Privately-lead actions may differ in the procedures employed and reports required; however, the guidance in this section indicates the general methods to be used.

4.3.1 Data Management for Scoping

Scoping objectives and activities are described in chapter 2. Scoping is the initial step of a remedial response, and the existing site data gathered and assessed during scoping define the subsequent tasks.

The most important information or reports produced to support and document the scoping task include:

- Site background, including a description of the problem
- Site chronology
- Site map
- Site-specific plans for QA/QC, health and safety, institutional issues, and management procedures
- Sampling plan and map
- Final RI work plans.

The extensive information assembled in preparing these reports should be systematically filed so that it can be readily procured if needed to support the conclusions of the feasibility study. Suggested filing and document control systems are described in section 4.2.1. The rationale, results, and costs of scoping and other RI tasks should also be documented to support any future legal or administrative actions.

4.3.2 Data Management for Site Characterization and Sampling

Site characterization and sampling are conducted to verify existing data and to fill data gaps for subsequent and concurrent RI work. Guidance on conducting site characterization and sampling is presented in chapters 3 and 7. Documentation and record-keeping procedures are most important during site characterization and sampling because these steps produce the basic data used in making all subsequent decisions, including remedial technology selection and enforcement programs.

The most important aspects of data management in these steps are:

- QA/QC plans - to provide records of traceability, adherence to prescribed protocols, nonconformity events, corrective actions, and inherent data deficiencies

- Data security system - to ensure that records cannot be tampered with or accidentally lost or damaged

- Detailed work plan - to maintain timing and scheduling requirements with field work, laboratories, holding times, and data turnaround

- Sampling plan - to provide sampling guidance and to address all elements specified in chapter 3.

4.3.3 Data Management for Health and Safety Programs

An appropriate health and safety program includes the following elements:

- A statement of policy
- A medical surveillance program and insurance plan
- A training program for project personnel
- A management plan that defines responsibilities and authorities for health and safety functions
- Health and safety monitoring and standard operating procedures
- Equipment procurement, inventory, and maintenance
- Emergency response procedures
- Documentation and records management procedures.

Existing programs are based on widely accepted practices such as those found in the Safety Manual for Hazardous Waste Site Investigations (U.S. EPA, 1979a). Health and safety program documentation of particular importance during RI activities includes:

- Physicians' reports
- Site-specific health and safety plan
- Site visitors' log
- Personnel monitoring results
- Incident reports
- Nonconformity reports
- Site Safety Officer's daily log
- Team leader log

- Equipment calibration logs
- Personnel training documentation.

Further information on these aspects of the health and safety program is provided in chapter 5.

One unusual requirement of data management for health and safety programs is long-term data storage. Deleterious health effects from contact with hazardous materials may not show up for many years. Data must usually be stored for more than 30 years in order to document previous exposure to hazardous materials. These data could help determine if the employee's poor health in later years is related to expsoure. In order to ensure confidentiality of personal health status, records should be kept in the personnel files rather than site files.

4.3.4 Data Management for Institutional Issues

As explained in chapter 6 of this document, Superfund remedial activities involve institutional requirements including:

- Site access
- Community relations planning
- Coordination with other EPA offices, Federal agencies, and States.

Proper documentation of actions related to these issues will help minimize delays in the later phases of remedial planning and implementation. Equally important, this documentation makes it possible to reconstruct the events if EPA or its representatives are presented with any legal challenges related to their conduct of the RI.

The events leading to site access and the nature of the access (voluntary, nonvoluntary, emergency) should be clearly recorded and this record carefully stored in case it is required at a later date. Any agreements regarding the liability of EPA or its representatives during the RI should also be documented and safely stored.

Many requirements pertain to community relations during the RI phase. The Community Relations Plan is a guide to all community relations activities at a site. All actions taken in accordance with this plan should be documented and the records stored, but particular attention should be given to recording actions designed to inform the public about work at the site and public comments. The public comments are a critical input to the "Responsiveness Summary" that must be completed for the feasibility study.

Finally, a written record should be prepared documenting the coordination of efforts by EPA and its representatives with other EPA offices, Federal agencies, or States. Again, reconstruction of events may require the examination of the procedures used.

4.3.5 Data Management for Bench- and Pilot-Scale Studies

Bench- and pilot-scale studies are performed to determine the proper treatment of hazardous wastes on a site-specific basis. The general approach to bench and pilot studies is described in chapter 8.

A comprehensive data management plan should be completed before the initiation of any bench- or pilot-scale study. This data management plan should include:

- Detailed work plan by task, including estimates of the costs, man-hours, and schedule
- Statement of objectives, indicating the intended purpose of the work, such as a feasibility study or a design study. Adequacy of sampling should also be addressed
- Quality control and quality assurance procedures
- Methods for data collection, reduction, validation, storage, and transfer
- Criteria for technology selection or elimination.

The basic data management concepts for bench and pilot studies are similar to those for field sampling procedures. It is very important that this information be well documented because it is the basis for the design or selection of remedial technologies.

4.4 FINANCIAL AND PROJECT TRACKING

The ability to manage and evaluate progress during an RI depends on the availability of the appropriate financial and project tracking data. The collection, documentation, and reporting of these data should take a systems approach, including the following basic elements:

- Detailed work plan by task, including estimates of the costs, man-hours, and schedule associated with each task
- Detailed project tracking reports.

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Since RIs are generally conducted by several parties, including EPA contractors and subcontractors, State contractors, and responsible parties, the procedures used to document, report, and track these data vary greatly. One effective approach is described in the model statement of work (SOW) included in Appendix A. The final work plan developed by the remedial planning contractor and approved by EPA and/or the state should detail the schedule for each RI task.

Project tracking reports are critical for tracking both financial and technical progress. EPA has developed three monthly status reports typically submitted by 20 calendar days after the end of each reporting period. They are:

- Monthly Work Assignment Technical Status Report
- Monthly Work Assignment Financial Status Report
- Cumulative Project Costs Graph.

Suggested formats for these reports are given as Tables 4-3 and 4-4, and Figure 4-1.

The specific procedures for RIs conducted by other parties should be similar to those for the Federal-lead RIs but allow for special requirements relating to agreements, contracts, or arrangements. For example, State-lead RIs are conducted under a Cooperative Agreement. Generally, EPA and the State sign a separate agreement for each site, and the reporting provisions in the agreement can vary.

TABLE 4-3. SAMPLE STATUS REPORT FORMAT

MONTHLY WORK ASSIGNMENT TECHNICAL STATUS REPORT

WORK ASSIGNMENT NUMBER:

SITE NAME/ACTIVITY:

PREPARED BY:

DATE:

PERIOD (Month, Year):

COPIES:

1. Progress Made This Reporting Period - Description of progress made during the reporting period, including problem areas encountered and recommendations.
2. Problems Resolved - Results obtained relating to previously identified problem areas.
3. Anticipated Problem Areas and Recommended Solutions - Anticipated problems and recommendations including technical, cost, and scheduling implications for resolution. Actual or projected overruns should be discussed here.
4. Deliverables Submitted - Deliverables completed and anticipated, including deliverables to be submitted, dates of anticipated submittals, and reasons if due dates have been (or need to be) revised.
5. Upcoming Events/Activities Planned - Important upcoming dates, meetings, hearings, etc. Major tasks to be performed within the next reporting period, identification of decision points.
6. Key Personnel Changes - Any changes in key personnel assigned to the work.

(continued)

TABLE 4-3. (continued)

7. Subcontracting - Extent of subcontracting and results achieved. Efforts made toward small business, disadvantaged, and labor surplus area subcontracting.

8. Travel - Extent of travel, including identification of individuals and their labor categories, and the results of such travels.

9. Contract Laboratories - Experience with EPA contract laboratory service, number of samples sent, turnaround time, overall evaluation of service provided.

10. Percent Complete - Level of technical completion achieved, reported as percent complete for each task and as a single number for the total work assignment.

11. Schedule - Agreed upon date that deliverables are due and actual date deliverables were or are planned to be submitted. Any delay should be explained.

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Table 4-4. Sample Status Report Format

WORK ASSIGNMENT FINANCIAL STATUS REPORT

Work Assignment Number:

Site:
Activity:

Month Ending:

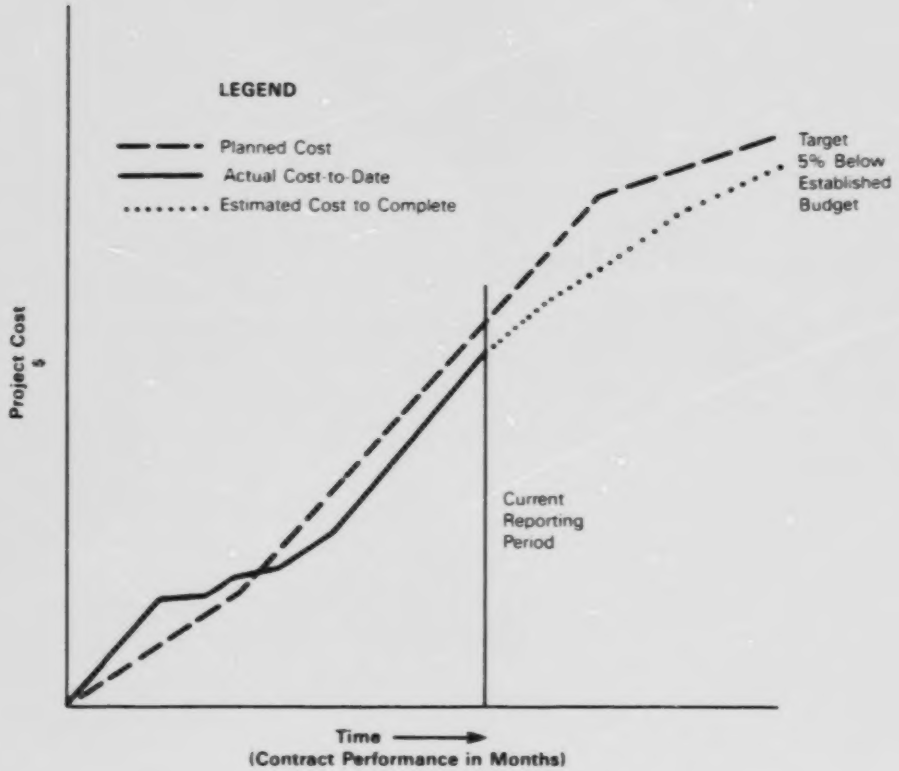
Project Start Date:
Scheduled Completion Date:
% Complete:

	Actual Costs			Estimated Costs			
Cost Element	Current Month	Cummulative to Date	% Spent	Cost to Complete	Cost to Completion	Budget at Completion	Variance at Completion
Contractor LOE Hours (#)							
Subcontractor LOE Hours (#)							
Total LOE Hours (#)							
Contractor Sec. Hours (#)							
Subcontractor Sec. Hours (#)							
Total Sec. Hours (#)							
Total Hours (#)							
Direct Labor ($)							
Equipment ($)							
Travel ($)							
Sub-Pool Cost ($)							
ODC's ($)							
Indirect Costs ($)							
Subtotal Cost ($)							
Base Fee ($)							
Total WA ($)							

WA Next 3-Month Projections:	Month 1	Month 2	Month 3	Total
Direct Hours (#)				
WA Total ($)				

Figure 4-1. Sample Cost Status Format

Work Assignment Number:
Site/Activity:
Job Number:
Reporting Period:



Cumulative Project Costs

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CHAPTER 5

HEALTH AND SAFETY PLANNING FOR REMEDIAL INVESTIGATIONS

5.1 INTRODUCTION

Protecting the health and safety of the investigative team, as well as the general public, is a major concern in hazardous waste site remedial investigations.

Hazards to which workers may be exposed include known and unknown chemicals, heat stress, physical stress, biological agents, equipment-related injuries, confined space entry, fire, and explosion. Many of these hazards are encountered in any type of field study, but exposure to chemical hazards, including toxicity, flammability, corrosivity, reactivity, and radioactivity, is a major concern for hazardous waste site workers. Toxicity hazards range from acute effects with clinical symptoms, such as headache, dizziness, and skin rash, to chronic or irreversible impacts, including impaired health, cancer, birth defects, and death. Symptoms of chronic effects may not appear for months or years; occupational cancers, for example, may have a latency period of 10 to 30 years or more.

In addition to the protection of site workers, the public's health and safety must also be considered. Remedial investigations frequently attract the news media, public officials, and curiosity seekers as well as representatives of potentially responsible parties and Federal and State agencies. Not only is the safety of these observers a concern, but their actions may affect the operations and safety of the investigative team. Other public health concerns include hazards and risks to the surrounding community from unanticipated chemical releases, fire and explosion, and gross negligence. Resolution of public health concerns often involves legal consultation as well as selection of the best technical and logistical approach.

5.1.1 Overall Approach

Investigation work at hazardous waste sites requires a strong commitment to the health and safety of site workers. Employers express this commitment in written health and safety programs and written site-specific safety plans. The health and safety program embodies the employer's philosophy, policies, and procedures regarding worker protection. The site-specific safety plan applies the program to a particular situation by prescribing the specific personnel, procedures, and equipment to be used.

All parties to a remedial investigation (i.e., Federal, State, and local agencies; owners; potentially responsible parties; and private contractors) should be aware of their potential liability for the health and safety of workers and of the public. Often, contracts or interagency documents specify the responsibilities for protecting public health. For example, contracts typically specify the posting of warning signs, the installation of fences, or the hiring of security guards. Strategies to alert, warn, or evacuate the public are generally planned with local community response agencies. Before initiating an RI, all parties should clearly understand their responsibilities for developing and implementing emergency procedures to protect the public.

5.1.2 Applicable Regulations to Protect Workers

Occupational Safety and Health Administration (OSHA) regulations are promulgated under the authority of the Williams-Steiger Occupational Safety and Health Act of 1970, PL 91-596. The stated philosophy of this legislation is "to assure so far as possible every working man and woman in the nation safe and healthful working conditions and to preserve our human resources." The following is a list of the regulations most pertinent to remedial investigations:

Citation	Title
29 CFR 1903	Inspections, Citations, and Proposed Penalties
29 CFR 1904	Recording and Reporting of Occupational Injuries and Illnesses
29 CFR 1910	Occupational Safety and Health Standards
29 CFR 1926	Safety and Health Regulations for Construction
29 CFR 1960	Federal Employee Safety and Health Programs
29 CFR 1975	Coverage of Employers under the Occupational Safety and Health Act
29 CFR 1977	Regulations on Discrimination against Employees Exercising Rights under the Occupational Safety and Health Act

The most specific regulations governing workplace health and safety are contained in 29 CFR 1910, Occupational Safety and Health Standards. Of particular relevance to RI work are the respirator standards (29 CFR 1910.134) and the toxic and hazardous substance standards (29 CFR 1910.1000 to 1500). Further, the OSH Act contains a general duty clause requiring employers to provide a place of employment free from recognized hazards. This clause is generally applied whether or not specific standards exist. This clause also places upon each employee the obligation to comply with OSHA standards, however, the final responsibility for compliance with the OSH Act requirements remains with the employer.

Federal employees, as well as contractor employees, are protected by OSHA regulations. State employees are not covered by OSHA regulations but may be covered by State regulations.

The health and safety of employees involved in Superfund activities are specifically addressed in Section 111(c) of CERCLA, which directs EPA, OSHA, and the National Institute for Occupational Safety and Health (NIOSH) to develop a program to "...include, but not be limited to measures for identifying and assessing hazards to which persons engaged in removal, remedy, or other response to hazardous substances may be exposed, methods to protect workers from such hazards, and necessary regulatory and enforcement measures to assure adequate protection of such employees." The NCP (40 CFR 300.71) expands this directive to require all private contractors working on Superfund sites to comply with OSHA regulations.

The Interim Standard Operating Safety Guides issued by EPA in September 1982 (U.S. EPA, 1982e) are generally accepted as the standard of practice for hazardous waste site work. The guides should be consulted before planning any RI activities. NIOSH prepared guidance manuals for Superfund activities that are currently under Agency review and may be released in early 1985. The Army Corps of Engineers and the Coast Guard have also published guidelines and procedures for protecting workers at hazardous waste sites.

Individual States may have occupational safety and health regulations more stringent than OSHA's. These should be consulted in order to determine their applicability and to ensure compliance.

One example of greater stringency in State regulation is State "Right to Know" laws, which require chemical labeling and worker notification of the hazards of workplace chemicals. The recently promulgated OSHA Hazard Communication standard (29 CFR 1910.1200) specifically applies only to employees involved in manufacturing, but various State "Right to Know" laws may apply to a wider spectrum of employers. The application of such regulations to workers at uncontrolled hazardous waste sites has not been tested in the courts. Presently, 15 States are covered by "Right to Know" laws: Alaska, California, Connecticut, Illinois, Maine, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Rhode Island, Oregon, West Virginia, and Wisconsin.

Some States have enacted "Good Samaritan" laws. Such laws limit the liability of workers who may give first aid or cardiopulmonary resuscitation (CPR) to co-workers or members of the public.

Professional recommendations and standards have been offered by such organizations as the American Conference of Governmental Industrial Hygienists, the American Society of Testing and Materials, the American National Standards Institute, and the National Fire Protection Association.

Many of their recommendations and standards have been incorporated into legal standards, while others, although not legally required, represent good practice criteria.

Other Federal and State regulations also contribute to the health and safety of RI workers. Department of Transportation regulations (49 CFR 171-178), for example, specify containers, labeling, and transportation restrictions for hazardous materials. These regulations cover the transport of compressed air cylinders, certain instruments, solvents, and all samples. The Resource Recovery and Conservation Act (RCRA) regulations may apply to the storage, transport, and disposal of investigation-derived materials, including disposable clothing, used respirator cartridges and canisters, and spent decontamination solutions.

5.2 THE HEALTH AND SAFETY PROGRAM

A health and safety program represents an employer's philosophy, policies, and procedures for assuring "safe and healthful working conditions." The health and safety requirements for remedial investigations are often far more rigorous, more technically oriented, and more expensive to implement than the requirements for routine worker protection programs. The following discussion offers guidance on the scope of a comprehensive health and safety program for remedial investigation workers.

5.2.1 Responsibility for Health and Safety

Responsibility for the health and safety program should be clearly delineated within an organization, as shown in Figure 5-1. The Health and Safety Director should report directly to the general manager. The Director should have the responsibility and authority for the development and implementation of the health and safety program.

A Site Safety Officer is designated to accompany each site investigative team and is responsible for implementing the site safety plan. A Site Safety Officer must be on-site at all times with the investigative team. This individual works with the field team leader, but in the event of a dispute regarding health and safety, the Site Safety Officer reports directly to the Health and Safety Director. The Site Safety Officer must be experienced in field operations and be thoroughly familiar with the use of air monitoring instrumentation, personal protection equipment, and decontamination procedures.

Each team member is responsible for complying with the health and safety program and the site safety plans, as well as alerting others to observed or suspected hazards. All team members must satisfactorily complete formal training in hazardous waste site operations before they begin site activities and should increase their proficiency with additional training.

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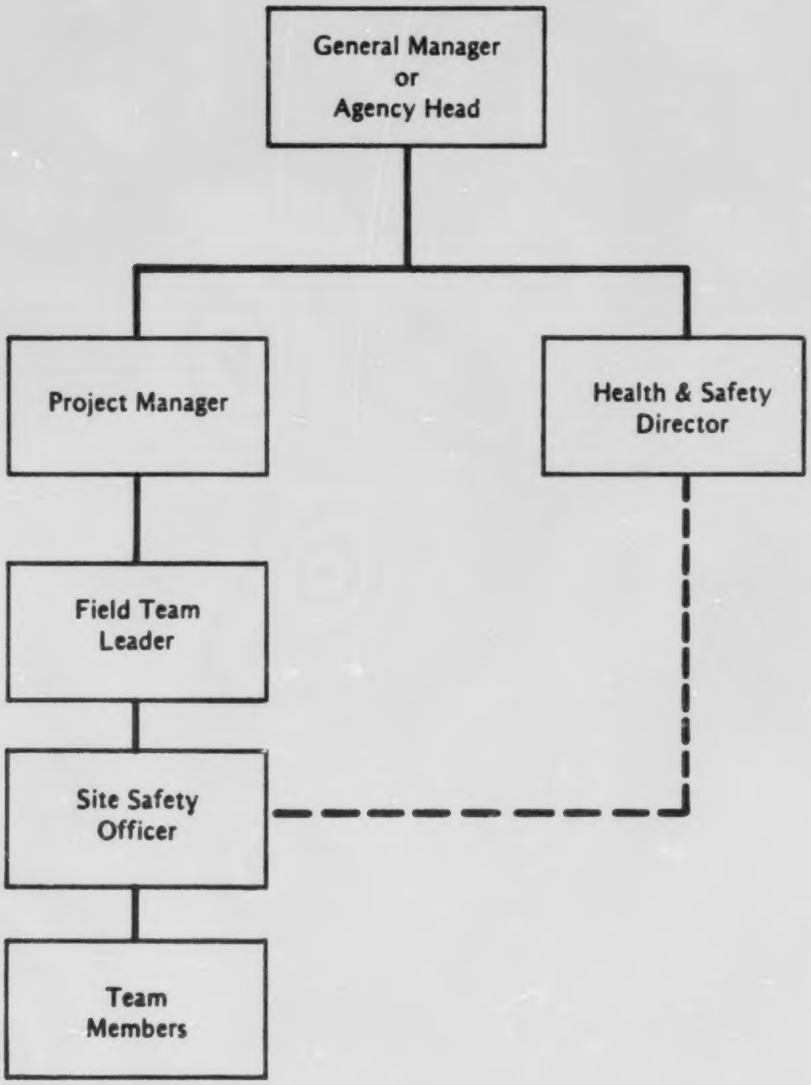
Figure 5-1. Organization Chart for Remedial Investigations


General Manager
or
Agency Head
Project Manager
Health & Safety
Director
Field Team
Leader
Site Safety
Officer
Team
Members

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5.2.2 Selection of Personnel for Remedial Investigations

Because work on uncontrolled hazardous waste sites is more hazardous than other environmental field studies, personnel should be informed of the risks prior to their assignment to such project tasks. This information should include a frank discussion of potential hazards, the medical surveillance and training programs, and the need for the use of personal protective equipment. At this point, some individuals may refuse the assignment for personal reasons.

5.2.3 Medical Surveillance Program

The medical surveillance program has three goals:

- To ensure through initial medical screening that workers at hazardous waste sites are in good health and have no medical conditions that might put them at an increased risk from this work
- To ensure the continued good health of each employee by periodic examinations
- To detect and treat any medical conditions potentially arising from work at hazardous waste sites.

The health and safety program should define all participants in the medical surveillance program, identify appropriate clinics and examination protocols, and address record-keeping requirements. All employees who may enter an uncontrolled hazardous waste site, perform work on or adjacent to an uncontrolled hazardous waste site, or handle samples from a site are candidates for medical surveillance. At a minimum, the program must require a medical examination by a licensed physician to certify the medical fitness of each worker who may wear a respirator on the job. This examination is required by the OSHA respirator standard, 29 CFR 1910.134, and must be performed within 12 months before respirator use. OSHA also requires specific medical protocols for workers who are exposed to certain toxic substances (29 CFR 1910.1001-1046).

The medical monitoring program and protocol should be approved by an informed occupational physician. Factors in determining the type of examination and frequency of re-examinations include the chemical and physical hazards at the site, the time spent in the field, and the chemical contaminants to which the worker may be exposed. The examination should include serum chemistry tests, such as liver and kidney function profiles, spirometer tests, and audiometry tests.

The initial examination should be conducted a few weeks prior to the worker's entry into the program in order to give the physician enough time to review pertinent laboratory data. Also, early examination allows managers time to select alternate personnel if any employees are found medically unfit for field work.

Periodic and exit examinations to monitor health status benefit both the employee and the employer. The physician must evaluate any change in the worker's health status from the initial medical exam to determine the need for additional surveillance or treatment. For the employer, results of periodic examinations indicate the success of the health and safety program and can reduce potential liability.

Supplemental examinations should be performed whenever there is an actual or suspected excessive exposure to chemical contaminants, or if the worker experiences symptoms of exposure (including headache, dizziness, nausea, blurred vision, and skin rash), a traumatic injury, or heat or cold stress. Prompt medical attention is essential for proper diagnosis and treatment and for allaying the employee's fears.

Recordkeeping is regulated by OSHA, which specifies that medical records must be retained for 30 years after termination of employment (29 CFR 1910.20). The confidentiality of these records should be preserved, in accordance with the Privacy Act of 1974 (PL 93-579). The Health and Safety Director must have access to the physician's certifications of medical fitness and must be apprised of all medical restrictions placed on occupational activities.

A health summary form, prepared by the physician or Health and Safety Director, is strongly recommended. This should be a one-page summary of the worker's health status, noting restrictions, current medications, allergies, and immunizations, as well as the name and telephone number of the occupational physician. The employee should bring this form to the site for consultation in case of a medical emergency. Figure 5-2 presents an example of a health summary form.

5.2.4 Training

Employees selected for work at hazardous waste sites usually have required skills in a particular area, such as geotechnology, engineering, chemistry, or hydrology. To perform these skills safely at a hazardous waste site, however, requires additional health and safety training.

EPA issued a directive on July 12, 1981 (EPA Order 1440.2) that specifies the health and safety requirements for EPA employees engaged in field activities. Under this Order, a minimum of 32 hours of instruction plus 3 days of work in the field with an experienced worker are required for health and safety training certification. Employees who will manage site activities must complete an additional 8 hours of instruction. All certified employees must complete a minimum of 8 hours of refresher classroom training annually. Although this Order applies only to EPA employees, State and private organizations have adopted several provisions of this Order as models for training certification prior to full field work participation.

Figure 5-2. Example Health Summary Form

HEALTH SUMMARY

Name: ______________________ Birth Date: __________

Sex: ______ Height: ______ Weight: ______ Blood Type: ______

Health Restrictions:

Allergies:

Current Medication:

Immunizations: Date:

Occupational Physician: ______________________ Telephone: ______

Personal Physician: ______________________ Telephone: ______

Family member(s) to notify in case of emergency:

______________ Relationship ______________ Telephone: ______

______________ Relationship ______________ Telephone: ______

All personnel should be familiar with potential routes (inhalation, skin or mucous membrane contact, and ingestion) by which toxic materials enter the body and specific measures to prevent exposure.

Given the hazards of RI work and the potential for exposure to toxic substances or for traumatic injury, first aid and CPR training assume great importance. Prompt use of correct first aid or CPR techniques is essential to protect all field investigators. OSHA requires that at least one person be trained in first aid if an infirmary, clinic, or hospital is not near the workplace (29 CFR 1910.151); it is advisable to have more than one trained person as a backup in case that one person is injured. Courses are available through the American Red Cross and the American Heart Association for a nominal fee.

The Site Safety Officer or other workers may be required to perform air monitoring to track potential worker exposures to airborne contaminants or to determine if on-site activities are causing contaminants to migrate off-site. These individuals must receive additional training in the use and limitations of air monitoring equipment, such as colorimetric tubes, total organic vapor analyzers, explosimeters, oxygen detectors, or radiation detectors. Because modifications in operational procedures and selection of personal protection equipment depend on the interpretation of air monitoring instruments, it is essential that the instruments be properly maintained and calibrated and that the readings be accurate and properly interpreted. The EPA Emergency Response Team in Edison, NJ, has prepared Standard Operating Safety Guides (revised November 1984) which provide further information on air monitoring requirements; this information will be released early in 1985 through the National Technical Information Service (NTIS), Springfield, Virginia, and the U.S. EPA, Cincinnati, Ohio.

Supplemental training should be considered for unusual site activities such as container opening, confined space entry, and sediment sampling. Simulated exercises will help train field investigators to perform these tasks safely and more efficiently. Often the logistics of these operations are complex, and dress rehearsals will help identify problems before they occur in the field.

Nonessential personnel should be kept off-site as much as possible. Occasionally, an untrained individual may desire or be required to visit a site to inspect or observe conditions or activities. The health and safety program should clearly describe measures to protect these visitors. Many programs prohibit visitors until they have completed the entire training program. Other programs prescribe an abbreviated training program for visitors and restrict the visitors' activities and access to the site. Visitors should be included in a medical surveillance program.

Special service contractors, such as well drillers, heavy equipment operators, and surveyors, should be required to show proof that all employees who will be working on or near a hazardous waste site, or who will handle potentially contaminated material from a site (samples, tools, or equipment) have received the appropriate medical examinations. These workers should be required either to complete the full training program conducted by qualified and experienced personnel and designed for field investigation workers or to enroll in a site-specific training program which addresses the hazards of that site, the use and limitations of personal protection clothing and equipment necessary for that site, and the standard operating procedures for work at that site. If site-specific training is incorporated into the program, qualified trainers and on-site supervisors must be identified.

EPA schedules training courses for hazardous waste site investigations, as well as specialized courses in specific aspects of site investigation. These courses, conducted by the Hazardous Response Support Division, Emergency Response Team, Cincinnati, Ohio, provide participants with fundamental information for protecting the public and the environment from chemical incidents resulting from releases of hazardous materials. Top priority for enrollment is given to EPA employees, although personnel from other Federal, State, and private agencies may enroll if space is available. EPA has made training grants available to States to conduct their own programs.

A few private firms and universities offer training. These courses may be tailored to the needs of an organization and in some cases may be offered at the organization's facility. A good training course will offer:

- Experienced instructors who have worked in the field and who have expertise in worker health and safety at hazardous waste sites.
- Sufficient equipment and instruments for each class participant to dress in protective clothing, wear respiratory equipment, handle monitoring instruments, and become familiar with the use of each. This is particularly important for training in respiratory protection.
- Both classroom instruction and simulated field exercises. The exercises should be organized so that every student participates.

Training records should be kept for each employee, including dates of instruction, curriculum, results of any examinations, and copies of certificates (course participation, Red Cross cards, etc.). Records should be maintained in a permanent personnel file.

5.2.5 Equipment

Specialized equipment for monitoring and personal protection is required for RI work. The health and safety program should addresss the selection, procurement, inventory, maintenance, calibration, and repair of this equipment. Often, depending on the size of the organization, one or more part-time or full-time equipment technicians are required.

Selection and procurement factors include not only the equipment specifications and necessary approvals but also delivery times and availability of spare parts and repair services. Portability, durability, and ease of operation, as well as intrinsic safety, precision, accuracy, sensitivity, and specificity, must also be considered in selecting equipment. An equipment inventory should list all currently owned equipment, including spare parts. A tracking system may be required if equipment is sent to different sites.

Equipment related to health and safety is broadly divided into two categories: monitoring and personal protection. Monitoring equipment includes:

- Explosimeter or combustible gas indicator
- Oxygen detector
- Radiation meter
- Organic vapor detectors
- Colorimetric tubes for specific compound monitoring
- Radiation badges for each team member
- Miscellaneous monitoring equipment, such as hydrogen cyanide or hydrogen sulfide detectors, dust monitors, and personal sampling pumps and detector dosimeter badges.

The personal protection equipment includes respirators, clothing, decontamination equipment, and emergency equipment; these items may be reusable or expendable. Communications devices may also be considered as personal protection equipment.

Selection and maintenance of respirators must conform to OSHA regulations (29 CFR 1910.134) and NIOSH/MSHA (Mining Safety and Health Administration) approvals. OSHA requires a written respirator policy that addresses the selection and use of respirators; specific requirements are outlined in 29 CFR 1910.134(b). Respiratory protection may include self-contained breathing apparatus (SCBA); supplied air respirators with associated compressors or air tanks, hoses and hardware; and air purifying respirators. For the air purifying respirators, appropriate canisters and cartridges must be provided. For personnel who require corrective lenses, respirator eyeglass inserts must be provided. Contact lenses are not permitted with respirator use. Their use at any time on a hazardous waste site should be addressed in the health and safety program.

Protective clothing is selected on the basis of resistance to chemical permeation and penetration, durability, and cost. Weather conditions, type of contaminants at the site, terrain features, and general site layout are other factors in selection. Eye protection (safety glasses, chemical splash goggles, face shield, or full face respirator) should be mandatory at all times. Steel toe, steel shank neoprene boots and hard hats are more or less standard, but gloves and other protective clothing (coveralls, splash suits, aprons, hoods, etc.) are specifically selected based on site-specific dermal and traumatic injury hazards and job functions. Disposable clothing is frequently specified because it minimizes decontamination problems; however, when selecting disposable coveralls, one must consider the likelihood of these garments ripping or tearing. Guidelines from manufacturers and recent publications should be consulted to select proper clothing and glove materials.

Communication is important both among team members (internal network) and with the outside world (external network). An equipment inventory may include intrinsically safe, voice-activated radios, whistles, alarms, and bullhorns for field communications. At remote sites, a CB radio may be required for emergency communication. In any event, two means of communication (primary and backup) are recommended for each network. Field expedient means, including hand signals, can be used.

Decontamination equipment may include solvents, solutions, water sprayers, steam cleaners, tubs, buckets, and brushes. Most of this equipment is readily available locally. The methods and equipment used in decontaminating personnel, personal protection equipment, sampling devices, air monitoring equipment, drill rigs and other heavy equipment, and sample containers must be selected for the specific work being done and the contaminants expected at the site.

Emergency equipment includes first aid kits, eye wash stations, fire extinguishers, stretchers, spill control equipment, and other response equipment. The site-specific health and safety plan should specify the emergency equipment required.

5.2.6 Standard Operating Procedures

Standard operating procedures have been developed by EPA to promote safety at hazardous waste sites. The EPA Interim Standard Operating Safety Guides (U.S. EPA, 1982e) describe procedures that provide uniformity from site to site, thereby simplifying the training and work plan preparation. Standard operating procedures for a comprehensive health and safety program include basic site rules, site organization, monitoring, levels of protection, communications, and emergency response. For each of these procedures, applicability, implementation, responsibility, and recordkeeping should be addressed in the site-specific plan.

EPA has defined levels of protection in the Interim Standard Operating Safety Guides to provide a common vocabulary to describe personal protection

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equipment. The four levels afford varying degrees of respiratory protection, dermal protection, and protection from traumatic injury.

- Level A is the "moonsuit," which consists of a totally encapsulated chemically protective suit with self-contained breathing apparatus, offering the highest degree of respiratory and dermal protection.
- Level B provides maximal respiratory protection through the use of supplied air or self-contained breathing apparatus; the level of dermal protection is selected on the basis of anticipated hazards.
- Level C incorporates an air-purifying respirator which is specific to the contaminant(s) of concern; the degree of dermal protection, as in Level B, depends on the anticipated dermal hazards. A supplied air escape pack may be required in some Level C ensembles.
- Level D is basically a work uniform.

Many variations are possible within each level, and these variations, e.g., gloves, coverall material, and splash garments, must be specified in the site health and safety plan. Criteria for this selection, outlined in the EPA Interim Guides, are best determined by professional judgment and research.

5.3 SITE-SPECIFIC HEALTH AND SAFETY PLANS

A written site-specific health and safety plan contains an assessment of the site hazards and specific procedures to protect workers from these hazards. The preparation of the plan entails a detailed review not only of all available site data, but also of the RI activities planned in order to evaluate potential exposures and the means to reduce these exposures. The health and safety plan is a document tailored to specific activities at a specified site under specified conditions. It details both procedures and equipment, as well as limitations on activities.

The site health and safety plan is essential in the planning process and is a valuable tool for all team members during later operations. It is frequently consulted during site operations, and a copy must be posted so that all personnel, including visitors, can easily read it. Because it contains instructions and telephone numbers for emergencies, it should be posted near the telephone and other communication equipment.

Although the site safety plan is of necessity detailed, conditions at a site will inevitably change, either naturally with time or through the activity of various parties, including the RI team. Accordingly, a procedure for modifying the site safety plan must be specified in the health and safety program. Many programs specify that a modification agreed to by the team leader and Site Safety Officer can be telephoned to the Health and Safety Director for verbal approval. Other programs require written approval of modifications to the site safety plan in order to minimize potential misunderstandings. Regardless, any modifications to the original site safety plan should be clearly marked on the posted plan and explained to all team members.

5.3.1 Preparation and Approval

The site health and safety plan should be prepared concurrently with the sampling plan. Early preparation of the health and safety plan is valuable in identifying potential problems, including the availability of adequately trained personnel, equipment, and funds. Inputs to the plan include a detailed site description and maps, results of previous sampling activities, and field reports. The plan preparer should review all information about the site. At the same time, the preparer must review all proposed activities to identify potentially hazardous operations and exposures. Professional judgment is required to evaluate site conditions and prescribe appropriate protective measures. Each investigation plan will vary as to degree of planning, special training, supervision, and protective equipment. The Health and Safety Director must give final approval to the plan. Because of potential liability concerns, each employer is responsible for approving health and safety plans for its own employees. The plans must conform to the agency's or firm's health and safety program.

5.3.2 Site Description

The site health and safety plan starts with a brief description of the site, including location, topography, climate, history, current status of wastes and other materials on-site, legal status, site security, and a summary of the waste types, quantities, locations, etc. The description is brief because all of the data are given in other documents. The availability of resources, such as roads, water supply, electricity, and telephone, is reviewed. This introductory section also states the purpose of the remedial investigation and lists the planned actions and dates. This description is important because it is the basis for the prescribed protective strategies. Changes in the site or activity descriptions may signal the need to revise the plan.

5.3.3 Hazard Evaluation

Toxicological data on the wastes known or suspected to be present are summarized. Particularly important is an analysis of exposure routes and information regarding permissible exposure levels, such as the threshold limit values (TLVs) or OSHA permissible exposure limits (PELs). An analysis of synergistic or additive effects should be included. Because of the rapid growth of research in this area, current information on toxicity is as essential to this analysis as is a basic knowledge of toxicology. Many of the sources listed in the bibliography are useful texts for hazard evaluation. In addition, EPA, the National Institutes of Health, and other agencies maintain online toxicology data services for subscribers and member libraries. These services include Medline, Toxline, and Chemline, which provide toxicity data and information on exposure symptoms and effects, as well as guidance on proper protection and decontamination. The Chemical Information Resources Handbook and OTS Information Architecture Handbook are additional sources of information.

Toxicity may be characterized by dose-response relationships. A concentration or dose, termed the threshold limit value, is sought below which no toxic effect is observed. Toxicity effects are a function of the specific chemical agent, synergistic effects with other chemical agents, dose, route of exposure, and individual susceptibility. Thus, for a full assessment of these hazards, each contaminant must be identified, the concentrations must be measured, the routes of exposure must be evaluated, and the overall health status of the worker must be medically reviewed. Often, some of this information is unavailable. Accordingly, the personal protection recommendations should be conservative to allow for missing information.

Threshold limit values for occupational exposures have been published for approximately 600 of the over 60,000 known chemical substances in commercial use. Even for these 600 substances, the cancer-causing potential is inadequately characterized (American Conference of Governmental Industrial Hygienists, 1984). The National Toxicology Program of the Department of Health and Human Services has embarked on a major program to identify carcinogens. Its 1983 annual report lists 117 substances known or reasonably suspected to be carcinogens. Also, the International Agency for Research on Cancer (IARC) has published a series of monographs evaluating carcinogen risk of numerous chemicals to humans. Many of the substances studied by these agencies have been identified at hazardous waste sites. The mutagenic and teratogenic impacts, which lead to birth defects, miscarriage, sterility, and chromosomal abnormalities, of the 60,000 known chemical substances are even less well characterized. Exposure to carcinogens, teratogens, and mutagens should be reduced to the lowest possible level in order to avoid long-term effects.

The hazard evaluation also examines physical factors, such as potential heat stress, frostbite, noise, radiation, falls, electrical shock, heavy equipment use, unstable ground or structures, and barriers. Any biological hazards (poisonous animals, insects, or plants) should also be addressed.

The best protection strategies must first and foremost protect the worker from known or reasonably anticipated hazards. The strategies must be practical for use in the field and not introduce greater hazards. For example, manual dexterity, field of vision, and agility may all be reduced by the use of personal protection equipment. Also, the use of chemically protective impermeable clothing, especially when combined with the physical stress of carrying 25 to 50 pounds of protective gear, promotes the onset of heat stress, even when ambient temperatures are low. The site safety plan must strike a balance between adequate protection, local conditions, and increased worker discomfort. However, under no condition should comfort be a deciding factor in the selection of protective ensembles.

The need to accomplish RI tasks within budget constraints is a foremost concern. However, short-term savings should be weighed against the cost of long-term liability for loss of well-being and health which might result from inadequate protection.

5.3.4 Monitoring Requirements

The monitoring requirements are based on the hazard evaluation. They should be as specific as possible, although for many sites, total organic vapor analyses, rather than compound specific analyses, are most practical.

One of the biggest problems in protecting on-site workers and the nearby community is the virtual impossibility of identifying and quantifying potential exposures from every contaminant on the site in real time. By the time laboratory results are available, site conditions may have changed or the RI field work may be complete. Real-time analytical techniques and instrumentation are severely limited in applicability. A major constraint is the need for prior knowledge of the contaminants of concern in order to be able to select instrumentation and analytical standards. Survey methods, such as total organic vapors, have been developed to serve as indicators, but expert judgment is required to interpret monitoring data and to select optimal protection strategies.

5.3.5 Levels of Protection

The plan must describe the level of protection (A, B, C, or D, described in section 5.2.6) for each work activity (e.g., sampling, drilling, decontamination) and the modifications required for initial site entry. It may set criteria, generally based on the monitoring data, to upgrade or downgrade the level of protection. When the site contains chemicals of unknown concentrations and composition, a worst-case scenario should be assumed. Included in this section of the plan are recommendations for specific clothing, gloves, etc.

5.3.6 Work Limitations

Typically, a health and safety plan is designed for a specific set of activities. The plan describes limitations on these actions, such as prohibited access to certain high-hazard areas, and sets forth requirements for lighting, duration of work shift, etc.

5.3.7 Authorized Personnel

The plan describes the responsibilities of each team member, including the site team leader and Site Safety Officer. Approval of personnel by the Health and Safety Director helps to ensure that they have the proper medical and training certifications.

5.3.8 Decontamination

The requirements for decontamination are prescribed including equipment, solutions, and step-by-step procedures. One problem that may need to be addressed is the disposal of waste materials generated during the investigation. Disposal of these materials, which include decontamination solutions, drilling cuttings or fluids, disposable sampling devices, disposable clothing, gloves, respirator cartridges, and canisters, may require permits under RCRA.

5.3.9 Emergency Information

Every site health and safety plan should contain the emergency telephone numbers for police, fire, ambulance, and hospital and a map clearly showing the fastest route to the hospital. Other useful emergency information includes telephone numbers of the potentially responsible party (if known), home office, EPA, poison control center, and consulting physician. Inclusion of a copy of standard procedures for reporting emergencies, such as whom to call and what information to give, is also valuable.

CHAPTER 6

INSTITUTIONAL ISSUES

6.1 INTRODUCTION

Remedial investigations undertaken pursuant to CERCLA often involve institutional issues relating to Federal, State, and local regulations, policies, and guidelines. This chapter outlines the institutional issues related to various components of a remedial investigation, including site entry and data collection, community safety and health, community relations, and coordination with other agencies or organizations. Worker safety and health issues were described in chapter 5.

This chapter explains the institutional requirements and their potential affects on the remedial investigation. Compliance with these regulations is important not only to the remedial investigation but also to other phases of the response and to enforcement actions. The data collected during the remedial investigation are critical to enforcement proceedings and to the development and evaluation of remedial alternatives in the feasibility study; therefore, the validity of the data should be ensured by following prescribed procedures.

6.2 SITE ACCESS AND DATA COLLECTION

In order to protect all parties and to ensure that the data collected are admissible in legal proceedings, field personnel should enter hazardous waste sites only in accordance with legal procedures. The revised guidance on State participation in the Superfund remedial program (U.S. EPA, Office of Emergency and Remedial Response (OERR); September 22, 1982) indicates that the State, to the extent of its legal ability, is responsible for obtaining site access if EPA asks it to do so. However, it is important for the user to be aware of the site access considerations outlined below.

6.2.1 Consensual Entry

CERCLA section 104(e)(1) requires any person who handles hazardous substances to "furnish information relating to such substances and permit ... [representatives of the President or of a State] at all reasonable times to have access to, and to copy all records relating to such substances." Section 104(e)(1) also authorizes the representatives to enter establishments where hazardous substances have been located and to inspect and obtain samples in order to determine the need to respond to a release or to enforce the provisions of Title I of CERCLA (Hazardous Substances Releases, Liability, Compensation). CERCLA legislative history makes clear that government contractors are considered representatives of the President or of the State and are authorized to perform inspections.

Before attempting to enter a site, the inspector should give advance notice of the inspection to the owner of the site. Surprise inspections can be detrimental to the investigation process. The inspector should obtain the owner's verbal consent for the inspection or investigation. In cases where difficulty in entering is anticipated, the inspector should attempt to obtain the site owner's consent in writing. If the site owner (who is identified during the preliminary assessment) is not available, the inspector should contact the site operator or other person in charge.

The inspector should make clear that he or she is a contractor or government employee when requesting access to a site. Field personnel must avoid even the appearance of threatening or coercing the person in charge of the site to gain entry; otherwise all data collected during that inspection may be legally invalid. The person in charge may withdraw consent at any time; if this occurs, all field personnel should immediately leave the site (later entry, if necessary, would be nonconsensual). All data collected until consent is withdrawn are legally valid. Observation from publicly accessible property may continue after consent is withdrawn, but mechanical aids such as binoculars and detection equipment may not be used in such observation. The person in charge may also give consent with restrictions, such as execution of hold harmless or confidentiality agreements. Requiring such agreements should be treated as a refusal of entry; however, minor restrictions that do not compromise the remedial investigation may be accepted.

6.2.2 Nonconsensual Entry

The person in charge of a site has the right to deny entry unless there is a warrant or court order procured. If one owner refuses entry and another consents or if the owner or person in charge cannot be located, the inspector should assume that entry is refused. If access is denied, the inspector should note the name of the person refusing entry, the date and time, the reasons given for refusal, and any other relevant information. The field personnel should then leave the site, and the inspector should notify the Regional Enforcement Attorney and the Deputy Project Officer, who generally will apply for a warrant or court order. The inspection should be conducted in strict accordance with the warrant or court order. To ensure the security of field personnel, they should be accompanied, if possible, by a U.S. marshall, who is primarily charged with executing the warrant. If violence is threatened, other security measures may be necessary.

6.2.3 Warrantless Entry

In an emergency when there is not enough time to obtain a warrant, a warrantless inspection is permissible. Emergencies include potential imminent hazard situations or situations where the evidence may disappear or be destroyed. Nonconsensual entry without a warrant should not be attempted without the assistance of a U.S. marshall. If possible, the user should attempt to obtain a warrant during the time necessary to gain the marshall's assistance because entry with a warrant is less likely to be challenged in the field or in court.

6.2.4 Confidentiality

If the person in charge of a site claims that certain information is confidential (i.e., entitled to protection under section 1905 of Title 18 of the U.S. Code) and this claim is not rejected by the appropriate EPA legal office, such information must not be disclosed to unauthorized persons. Failure to protect confidential information can result in criminal penalties against the inspector and civil suits against the lead agency. If a claim of confidentiality is made and consent is not withdrawn, information may still be collected, provided that the general EPA procedures for handling confidential information are followed (see 40 CFR part 2). Generally, the person collecting the information should have confidential business information (CBI) clearance, and files claimed to be CBI should be kept separate from other files and secure.

6.2.5 Sampling

CERCLA section 104(e)(1)(B) imposes certain requirements on sampling undertaken pursuant to CERCLA. Before leaving the site, field personnel must give the person in charge of the site a receipt describing the samples obtained and, if requested, a portion of each sample equal to the portion retained. (Before sampling starts, the inspector should ask the person in charge whether split samples are desired.) CERCLA also requires that the results of sample analysis be furnished promptly to the person in charge of the site. All samples should be handled according to chain-of-custody guidelines (see chapter 3).

6.2.6 Control of Contaminated Materials

Contaminated materials are commonly generated during a remedial investigation. Such materials include decontamination solutions, disposable equipment (e.g., protective clothing), drilling muds, and materials contaminated by spills during the investigation. The work plan for the remedial investigation (the sampling plan) should describe the means of controlling contaminated materials.

Control of contaminated materials involves minimizing the quantities generated and adequately storing and disposing of the material. The contaminated material may contain hazardous substances in sufficient quantities or concentrations to classify it as hazardous waste under RCRA (see 40 CFR part 261 subparts C and D). If so, storage and disposal should comply with the technical requirements of RCRA. This reflects a policy regarding the applicability of EPA-administered permit programs to action taken pursuant to CERCLA. This policy has not yet received Agency approval. Waivers to this policy may be granted on a case-by-case basis with the written approval of the Assistant Administrator for the Office of Solid Waste and Emergency Response (OSWER). The user should conform to the technical requirements for the storage, disposal, or other handling of the contaminated materials in order to protect public health and welfare and the environment.

6.3 LIABILITY

Injury to workers or third parties or damage to property during a remedial investigation can lead to liability claims against field personnel, their company, or the lead agency (e.g., EPA or the Coast Guard). The user of this document should be aware of liability provisions in order to act appropriately in the event of injury or illness to workers and avoid actions that would make the contractor or government liable for damages.

6.3.1 Workers Compensation

Under workers compensation, an employer is usually exempt from damage suits initiated by its employees, and all benefits for personal injury caused by accidents arising out of and in the course of employment are paid out of pre-established funds financed by insurance premiums. Employees at CERCLA sites are included under different workers compensation systems, depending on the employer. All Federal employees, including EPA and Coast Guard personnel, are covered by the Federal workers compensation program administered by the Department of Labor. All State employees are covered under individual State programs. Private employees, such as contractor personnel, are covered under individual State workers compensation laws, which generally require insurance or other demonstrations of financial ability to compensate workers.

If a State or contractor worker is injured, the first step in processing a claim is filing a report with the State agency administering the workers compensation system. If a contractor is located in one State and is investigating a site in another, the worker may have the option of filing the claim in either State, depending on State laws. Then, in most cases, the employee and employer reach an agreement based on the particular State regulations concerning benefits and coverage, and the worker is compensated by the employer or the employer's insurance company. If there is some dispute, the worker appeals the case to the State agency.

6.3.2 Federal Liability

Although a worker might sue the United States for damages resulting from work at a Superfund site, there are limitations on the liability of a Federal agency. The Federal Tort Claims Act (FTCA) provides statutory authority for recovering losses from the government under certain conditions, but recovery of losses from the government is difficult. As interpreted by the Supreme Court, the Government is immune from liability for negligence at the planning or policy level, but not at the operational level (i.e., negligence of a regulatory official in prescribing safety precautions at a site).

CERCLA section 107(d) precludes liability of the government, firms, or individuals for "actions taken or omitted in the course of rendering care, assistance, or advice in accordance with the National Contingency Plan or at the direction of an on-scene coordinator" with respect to a release or threat of release of a hazardous substance. This section, however, does not preclude liability for damages that result from "gross negligence or intentional misconduct."

6.3.3 State Liability

If the State is responsible for a response (or certain aspects of a response) to the release or threat of release of a hazardous substance, the State may be liable for damages resulting from those response actions. CERCLA section 107(d) limits the liability of the State to damages resulting from gross negligence or intentional misconduct (see section 6.3.2); the liability of the State may be further limited by State tort law. For example, in some States, gross criminal negligence by the State must be shown before any State entity can be prosecuted.

The State's liability for contracted work varies depending on the contract. Some States (e.g., New Jersey and California) include language in contracts that indemnifies the State from liability for third-party claims, placing the responsibility on the contractor.

6.3.4 Employer Liability

In most cases, employers such as contractors would not be liable for injuries or illnesses incurred by workers at a Superfund site; disabilities normally would be compensated through workers compensation. In several recent cases, however, the courts have ruled that there are situations where an injured worker can sue an employer. These situations include intentionally

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harmful acts by employers and injuries resulting from faulty equipment manufactured and provided by the employer. It is important to note, however, that the principles of liability depend on State law and differ markedly from State to State.

Contractor liability is limited by CERCLA section 107(d) to damages resulting from gross negligence or intentional misconduct (see section 6.3.2). Contractors of the Federal Government (e.g., the REM/FIT zone contractors) are, as specified in the contracts, generally not liable for damages to third parties resulting from response actions. Other contractors, including contractors to States or private parties, may, however, be liable to third parties in some instances, depending on the contract.

6.4 SUBCONTRACTING FOR SPECIAL SERVICES

The user may need to arrange for services (e.g., sample analysis, engineering, construction) that cannot be supplied through existing contract vehicles. For example, samples requiring unusual analytical equipment might be analyzed in a laboratory that is not a part of the Contract Laboratories Program (CLP).

Knowledge of the various contract types and methods for selecting a contractor will reduce cost uncertainties and ensure timely, quality work. Available guidance should be reviewed to obtain relevant information. Such guidance may include EPA or State procurement regulations, or the EPA Project Officer's Handbook. The appropriate contracting or procurement office (Federal, State, or private) should be contacted for assistance and guidance in the contracting process. Careful review and selection of the most qualified firm will help to ensure the quality of the work and reduce cost uncertainties.

6.5 COMMUNITY SAFETY AND HEALTH

One of the primary concerns during a remedial action is the health and safety of the people adjacent to the site and of the site workers. The safety of the people living near the site is the responsibility of the local community, with the field contractor and EPA personnel assisting when necessary. Worker safety is protected by appropriate Federal and State agencies and regulations, as described in chapter 5. Before a field investigation team is permitted on-site, a comprehensive site-specific safety plan must be developed (see chapter 5).

Before work begins at a site, the neighboring communities should be informed of the anticipated site work and any potential hazards it might pose to the community. A Federal or State government regulatory official knowledgeable in safety should meet with local fire, police, and other safety officials to discuss the safety of the community and answer related questions (see section 5.2.1). The community is responsible for formulating a contingency plan for community safety, but EPA personnel should assist when needed. This coordination will help in obtaining the aid of the police and fire departments, if needed, and in ensuring a cooperative relationship with the local officials.

6.6 COMMUNITY RELATIONS DURING REMEDIAL INVESTIGATIONS

Community relations activities during remedial investigations are dictated primarily by the site-specific community relations plans (CRPs). A CRP details how EPA or the State will (1) inform the affected community about the site and (2) elicit community input into response decisions. A CRP must be prepared and put into action for every CERCLA response before site work begins, regardless of whether the response is being managed by program or enforcement staff or by the responsible parties. Thus, when the remedial investigation begins at a site, EPA or the State will have completed a CRP for that site and will have started the communications activities specified in the CRP.

Generally, CRPs should specify two types of activities: (1) providing periodic progress reports on the findings of the remedial investigation, and (2) eliciting and documenting comments and concerns from citizens, local officials, and community or environmental groups. These activities are discussed below.

6.6.1 Progress Reports

Citizens will want understandable, accurate information about the progress and findings of the remedial investigation. The CRP will specify the most appropriate methods for providing this information. The methods include:

- Informal meetings for distributing significant test results or other findings
- Meetings with individuals or groups affected by the results of health studies
- Briefings of local and State officials
- Progress reports and fact sheets
- News conferences
- A repository for site information at the local library, health office, or community center that contains approved technical documents, official phone numbers, and a copy of the CRP

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- Site visits
- A toll-free hotline staffed by EPA personnel qualified to respond to public inquiries.

Further guidance on these activities is provided in "Community Relations in Superfund: A Handbook, Interim Version" issued in September 1983 by the Office of Emergency and Remedial Response.

6.6.2 Eliciting and Documenting Community Concerns

Effective community relations programs give members of the affected community opportunities for input. Citizens should be encouraged to ask questions and suggest response actions. EPA or the State must respond to those questions and concerns and consider them in response decisions, whenever possible. The issues raised by the community may affect subsequent investigatory actions or suggest important issues for EPA or the State to consider in selecting an appropriate remedy for the site.

Ultimately, EPA or the State will prepare a Record of Decision (ROD) describing the remedy selected for the site. Superfund community relations policy requires EPA staff to prepare a responsiveness summary to be included with the ROD. This responsiveness summary describes the comments and concerns raised by the community during the RI/FS process and explains how EPA addressed those concerns in selecting an appropriate remedy. Therefore, any citizen concerns raised during the remedial investigation and EPA's response to those concerns must be documented for use in preparing the responsiveness summary. The activities listed in the previous section are useful techniques for encouraging community input during the remedial investigation.

6.7 COORDINATION

Many of the institutional considerations discussed above involve coordination with other agencies or local officials; in addition, it may be necessary to coordinate with other EPA offices, Federal agencies, and States.

6.7.1 Enforcement Personnel

If a site is the subject of litigation or administrative action or targeted for enforcement, it is essential that the user of this document coordinate closely with the regional enforcement personnel. In most cases, both the regional counsel and the program officer assigned to the site should be contacted. Close coordination is critical to ensure (1) the collection and documentation of sufficient data for enforcement purposes (see chapters 3, 4, and 7) and (2) strict compliance with the community relations plan for the site, especially regarding the disclosure of information to the public.

6.7.2 Department of Interior (DOI)

The Department of Interior may provide assistance in performing remedial investigations through its various services and offices. The Fish and Wildlife Service may be consulted for information on endangered species, critical habitats, and wetlands in the vicinity of the site. The Bureau of Land Management (BLM) should be consulted prior to performing investigations on-site on Federal lands managed by the BLM, and may also be able to provide background information on the site setting and history. Additionally, the BLM may be able to assist in investigations of sites abutting BLM-managed lands by providing access to the site.

In addition, the Office of Environmental Project Review (OEPR) (under DOI) has specific duties under CERCLA for evaluating danger to natural resources resulting from releases of oil and hazardous substances. Under the EPA/DOI Memorandum of Understanding (September 2, 1983), OEPR is responsible for performing preliminary surveys of damages to natural resources when notified of the need for such a survey by EPA's Office of Waste Program Enforcement (OWPE). In performing the preliminary survey, OEPR may require data developed during the remedial investigation, or may develop data which should be incorporated in the investigation. OWPE is the EPA point of contact regarding preliminary surveys conducted under this agreement.

6.7.3 U.S. Army Corps of Engineers

As the Federal authority responsible for the design and construction of Federal-lead remedial actions, the Army Corps of Engineers should be consulted in planning and performing remedial investigations to ensure that the investigation provides the data necessary for final action design, as well as evaluation of alternatives. The Corps should be consulted as a data source when sites are located near or adjacent to Corps projects, since the Corps may have developed data on local soils, ground water, and surface water which would be of use in the investigation. Additionally, Corps projects near a site undergoing investigation may need to be considered in developing remedial alternatives for the nearby site. Such a case occurred at the Brodhead Creek site in Stroudsburg, PA; therefore, data on project designs and construction may need to be obtained as part of the RI.

6.7.4 U.S. Coast Guard (USCG)

The USCG has specific responsibility for responses to spills of oil or hazardous substances in the coastal zone under the terms of NCP section 300.33 and the Memorandum of Understanding between the EPA and the USCG (February 1, 1982). In investigating sites involving coastal areas, the USCG should be consulted to obtain data on spills which may have occurred and contributed to the contamination problem at the site and previous response operations (i.e., immediate removals performed by USCG). Additionally, the USCG may be able to provide assistance in performing the investigation of sites located in coastal waters by providing supporting equipment and advice on procedures for performing the investigation.

6.7.5 National and Regional Response Teams

The National Response Team (NRT) is a group of people consisting of representatives from 12 agencies including representatives of EPA and USCG as chairman and vice chairman, respectively. The NRT performs three basic kinds of activities: planning and coordination, operations on-site, and communications. The RRT is a regional response team for planning and preparedness actions for a response. The RRT consists of representatives from State and local agencies who are coordinated to evaluate the effectiveness of, and recommend changes in, the agencies involved in a response.

The NRT and RRT can assist in the performance of remedial investigations through several means. The NRT and RRT provide an existing structure for coordinating the activities of Federal and State agencies, and their contractors, involved in the response. The teams can be used as a point of contact for collecting information that may be pertinent to the remedial investigation from member agencies, and for obtaining necessary easements or access rights across Federal lands. Additionally, the teams can provide data on any past emergency response actions at the site, and provide support in response to emergencies that may occur during the remedial investigation. The teams may also provide advice on precautions to be taken during the remedial investigation and on the planning of the investigation.

6.7.6 Agency for Toxic Substances and Disease Registry (ATSDR)

ATSDR within the Department of Health and Human Services is responsible for monitoring the health of workers and citizens at or near CERCLA sites and for ensuring the availability of adequate health care services. In this capacity, ATSDR can contribute to the remedial investigation. ATSDR also conducts and issues health studies and health assessments. After determining that ATSDR expertise is required, the user should contact the regional ATSDR representative.

A memorandum of understanding (MOU) between EPA and ATSDR is being developed to define the responsibilities of these agencies in responses undertaken pursuant to CERCLA. The MOU, when approved by both agencies, will provide more detailed procedural guidance relating to ATSDR involvement in remedial actions.

6.7.7 United States Geological Survey (USGS) and State Geologists

The user may want to consult with USGS district offices to gather basic technical information about a site. USGS can be employed through either the existing EPA Headquarters/USGS Inter-Agency Agreement or through a State/USGS Cooperative Agreement. In addition, many States employ geologists who can provide valuable technical information about sites in their State. State geologists may be especially useful when a full-time geologist is not needed at the site. State geologists may be contacted through State departments of natural resources.

6.7.8 Other Organizations

Coordination with other organizations may also benefit the investigation. Examples include:

- Private associations, such as the Association of State Geologists or the American Institute of Professional Geologists, may be able to provide specialized information about a site.
- Local universities may be able to provide laboratory or other facilities useful to the investigation, and faculty members experienced in many disciplines, may contribute useful information.
- Local extension services may be able to provide information on local agronomy and agriculture.
- The Soil Conservation Service has expertise in soil types and characteristics.

CHAPTER 7

SITE CHARACTERIZATION

7.1 INTRODUCTION

Site characterization is the most critical portion of the remedial investigation process. The objective of site characterization is to collect and analyze enough information to determine the:

- Necessity for remedial actions
- Extent of any remedial actions
- Feasibility of potential remedial actions.

Thus, site characterization activities provide the data to support the decisions made in the concurrent feasibility study.

Typical interactions associating site characteristics with effects on human health and the environment are shown in Figure 7-1. As this diagram indicates, the possible interactions at any site are many and complex, and special efforts may be needed to limit the site characterization process to only the necessary data.

This chapter provides guidance for conducting site characterization studies that will provide the needed data efficiently and cost effectively. Two important aspects of site characterization are discussed: (1) types of investigations and resulting data assessments, and (2) programmatic factors that should be considered in selecting appropriate site characterization efforts.

The scope of potential interactions (shown in Figure 7-1) suggests that many technical areas can be studied. Characterization work may be needed in the areas of waste properties, site engineering, geology, ground-water and surface-water hydrology and chemistry, geochemical interactions, atmospheric processes, effects on the environment, effects on human health, and numerical modeling. The approach to site characterization work is described in section 7.2. Through a discussion of the technical investigations and assessments that may be used, section 7.3 provides guidance for establishing an appropriate site characterization effort.

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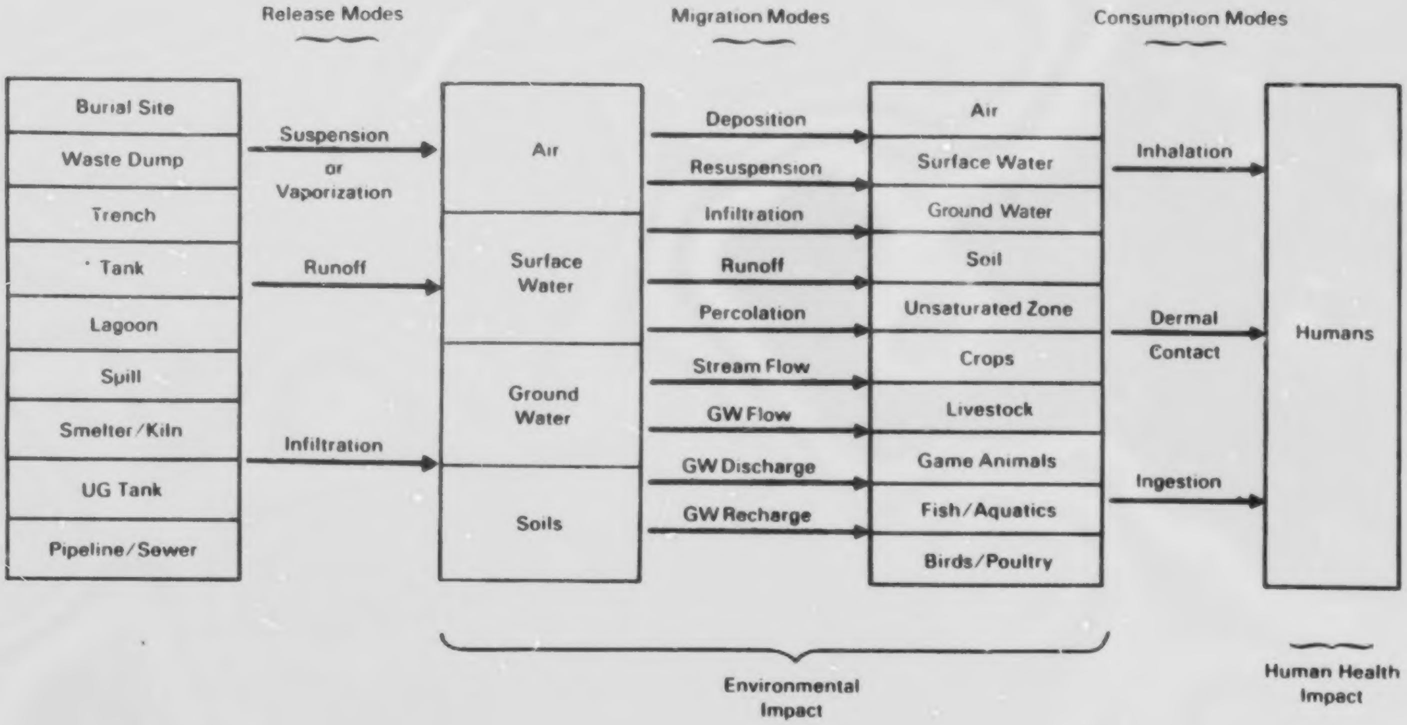
Figure 7-1. Overview of Effects and Interaction at a Representative Hazardous Waste Site


Release Modes
Migration Modes
Consumption Modes
Burial Site
Waste Dump
Trench
Tank
Lagoon
Spill
Smelter/Kiln
UG Tank
Pipeline/Sewer
Suspension
or
Vaporization
Runoff
Infiltration
Air
Surface Water
Ground Water
Soils
Deposition
Resuspension
Infiltration
Runoff
Percolation
Stream Flow
GW Flow
GW Discharge
GW Recharge
Air
Surface Water
Ground Water
Soil
Unsaturated Zone
Crops
Livestock
Game Animals
Fish/Aquatics
Birds/Poultry
Inhalation
Dermal
Contact
Ingestion
Humans
Environmental
Impact
Human Health
Impact

Programmatic factors resulting from the legislative and programmatic basis for hazardous waste site investigations may influence the site characterization activities. These factors are presented in section 7.4. Guidance on timing and cost of required activities is provided in section 7.5.

7.2 APPROACH TO SITE CHARACTERIZATION

The remedial investigation consists of various activities to support the concurrent feasibility study. The approach is designed to provide information to be used in determining appropriate response alternatives. As such, the remedial investigation must be integrated with the feasibility study or other requirements such as enforcement actions to ensure that inputs are available when needed. For example, various levels of sophistication can be incorporated into the investigation activities based on the size and complexity of the site and on the availability and retrievability of the data. This multi-level approach provides information to satisfy the successively more refined levels of the feasibility study. This results in an accurately focused, cost-efficient study.

The RI process defined in this manual consists of three investigation levels: characterization (I) and two levels of field studies (II and III). The focus of each level will depend on the fund-financed remedial, enforcement, or health study objectives of the project. All three levels need not be performed. The investigation may terminate at level I or II or move directly from level I to level III; these variations could depend on the utility of existing data, the urgency of site problems, and the specific objectives of the RI/FS.

Data collection and analysis do not stop at a particular level but only when sufficient data are available to justify remedial decisions. Thus, the scope of data collection and analysis must be adjusted to meet specific site needs. In some cases, a qualitative assessment of a relatively small data base may be sufficient for selecting remedial alternatives for obvious threat situations (e.g., removal of drums which are leaking). In other cases, a quantitative analysis of a larger data base may be necessary (e.g., large contamination zone). Sufficiency of data depends on the technical appropriateness of the sampling, analysis, and evaluations to be conducted and the judgment of responsible decision-makers. The data may be deemed sufficient at any RI level, but must be sufficient to select the most cost-effective remedy.

Level I characterization (Scoping, chapter 2) involves the compilation of existing data to provide as complete a picture as possible of the overall magnitude of problems at a site and to develop a plan for subsequent detailed characterization efforts, if required. The level I characterization of sources, pathways, and receptors should allow a determination of potential hazards, including the known or suspected sources of contamination, the probable pathways by which these contaminants can migrate, and the potential receptors that are affected by contaminant migration. Level I characterization efforts utilize existing data including, but not limited to, information obtained from the Preliminary Assessment, Site Investigation, and Hazard

Ranking System, and should be conducted at all sites. This effort does not address the development of data to complete the site "picture," instead, data gaps or insufficiencies are noted for potential investigation. This level corresponds to the qualitative level of detail for an enforcement endangerment assessment.

In level II characterization, quantitative data are collected from various technical investigation methods (e.g., geologic or atmospheric investigations) to evaluate important site characteristics. This information is used for several purposes during the RI and FS. The level II characterization is used to:

- Produce data for the contamination assessment in the RI
- Produce a quantitative endangerment assessment to support an administrative action
- Develop and screen remedial actions in the FS and produce data for the public health and environmental assessments conducted in the FS
- Develop baseline data to evaluate the no-action alternative.

The level II characterization will generally be broader in scope and more detailed than the level I effort and will likely require the collection of considerable field data. Sections 7.2 and 7.3 of this chapter explain the several types of investigations that may be conducted in order to develop the assessments listed above.

The need for a complete level II characterization effort should be weighed against the results obtained in level I, the requirements of the feasibility study, and the potential for enforcement activities or health studies. A limited level II investigation, in which only a few samples are collected, may be warranted:

- Whenever an initial response is implemented and post-action site data are required to determine its effectiveness
- Whenever data are insufficient to permit scoping (i.e., level I) of the remedial investigation.

The results of level II may be sufficient to complete the RI or indicate the need for more data to evaluate the feasibility of specific alternatives in detail. The decision that additional data are needed must be made quickly so that further mobilization costs are not incurred. Documentation for more studies (level III) should include the justification for additional study, specific data needs, and the recommended approach for collecting these data.

Level III characterization is used to collect additional data on sources, pathways, receptors, and environmental conditions needed for evaluation of alternatives in the FS. These data are used in quantitatively assessing the performance of the remedial technologies judged to be feasible, and in performing any required risk assessments associated with implementation of each remedial action. The level III characterization also includes bench and pilot studies which are discussed in chapter 8.

7.2.1 Characterization Activities

Site characterization provides quantitative data on potentially important site characteristics. Because several remedial technologies and alternatives may need to be evaluated, the characterization effort will be much broader in scope and more detailed than the preliminary assessment activities and will likely require considerable collection of field data.

In a few cases, two different levels of remedial investigations are advisable to ensure proper focus of the study. For example:

1. The site may be very large (more than 100 acres) and complex. Surveying all areas of a large site in great detail, only to find that the areas of interest are small subareas, would be a waste of resources. A better approach would be to conduct an initial screening study which would determine those areas requiring more detailed subsequent study.
2. Bench and laboratory studies may be needed to evaluate specific remedial action alternatives identified in the feasibility study. Such tests may include field-oriented work such as pump tests to aid in selection and design of well networks. This rationale for a second level of remedial investigation flows directly from the integration of activities with the feasibility study.
3. Enforcement actions may require greater definition of contamination and a more complete characterization of remedial technologies in order to support negotiations or litigation.

7.2.2 Data To Be Collected

The data that should be collected during site characterization include but are not limited to the following:

- Environmental Setting. Data to define the site and facility characteristics should be collected commensurate with potential remedial technology options. This information normally includes descriptions of the geography and layout of the site and surrounding areas; topography; waste source locations; waste type; geotechnical engineering considerations; normal and unusual meteorological conditions; surface drainage patterns; geologic features; ground-water occurrence, flow direction, and rate; biota at or near the site; and soil type and chemistry.

- Hazardous Substances. Analytical data should be collected to characterize the wastes completely, including type, quantity, physical form, degree of contamination, disposition (containment or nature of deposits), and facility characteristics affecting release (e.g., site security, and engineered barriers). These data may also be required to support decisions on removals or initial remedial measures prior to remedial actions.

- Environmental Concentrations. Analytical data on air, soils, surface water, and ground-water contamination in the vicinity of a site should be collected. These data should be sufficient to define the extent, origin, direction, and rate of movement of contaminant plumes. The data collected should allow an assessment of hazards posed by the site to the surrounding environment. Data should include time and location of sampling, media sampled, concentrations found, conditions during sampling, and the identity of the individuals performing the sampling and analysis.

- Potential Impact on Receptors. Data describing the human populations and environmental systems that are susceptible to contaminant exposure via the transport pathways from a site should be collected so that present or potential exposures can be assessed. Chemical analysis of biological samples will be needed. Data on observable effects in ecosystems may also be obtained.

- Remedial Action Effectiveness. Data relevant to the feasibility and effectiveness of proposed remedial actions should be collected. Because of the diversity of potential alternatives, specific investigations may be delayed until conclusion of relevant portions of the feasibility study.

7.2.3 The Philosophy of Necessary and Sufficient

It is EPA's policy that remedial investigations should be undertaken only to the extent "necessary and sufficient" to fulfill the requirements of subsequent remedial action implementation and/or legal enforcement proceedings. At any site, there is the potential for conducting investigations far beyond the needs of remedial responses or enforcement actions. The temptation to pursue such expensive studies should be avoided in favor of a balanced, justifiable, cost-effective approach that satisfies the site-specific objectives.

Therefore, it is important that the objectives and scope of the investigation are clearly defined early in the RI planning process, as described in chapters 2 (Scoping) and 3 (Sampling Plan). This permits the RI effort to focus on collecting clearly needed data and reduces the potential for repeated data collection activities.

The scope of the RI effort depends on the quality of existing data, key site problems, and FS and enforcement needs. These factors determine the study parameters and the sampling that will be sufficient to meet identified needs. When the scope of an enforcement RI is in doubt, the Office of Waste Program Enforcement or regional enforcement staff should be consulted.

7.2.4 General Characterization Methods

Whenever possible, methods that provide quantitative data should be used during site characterization. These methods are discussed further in section 7.3.1. Sampling plans (see chapter 3) should be devised to preclude biasing the results toward preconceived ideas about the site and the hazards it may pose. The advantages of unbiased sampling, however, should be weighed against the need for the information and cost and time constraints.

Characterization efforts may include:

- Review of existing data not found during the preliminary assessment.
- Discovery/quantification of hazardous substances and waste sources.
- Geophysical surveys to locate and characterize discrete sources.
- Geologic investigations to describe influences on ground-water movement and contaminant migration.
- Installation of observation wells or air monitoring stations.
- Hydrologic and atmospheric investigations of the contaminant transport systems.
- Sampling and analysis over a wide area to describe and quantify contaminants, contaminant distribution (horizontal and vertical), chemical characteristics of the migration pathways that may affect migration, and effects on the environment or human health. Ground water, surface water, sediments, surface soils, subsoils, atmosphere, biota, and/or waste sources may be sampled, depending on the characteristics of the site and the environmental setting.
- Integration of all data into an assessment of site characteristics and contaminant fate and transport. Development of quantitative numerical models of the site may be appropriate. Flow models can be used to determine potentially affected areas, whereas contaminant transport

models can quantitatively predict impacts that might not otherwise be obvious. Model development during this phase can aid in minimizing the amount of data collected by focusing attention on pathways and locations that are important to contaminant migration.

While these efforts are generally applicable to all sites, a specific scope of work is site-specific and should be developed on a case-by-case basis.

7.2.5 Assessments To Be Performed

The completion of site characterization should include the evaluation of data collected from the various types of investigations conducted in the RI and the compilation of these analyses into a contamination assessment describing the hazards posed by a site to support alternative development and analysis during the feasibility study. The remedial investigation data must be adequate to perform the technical, public health, and environmental evaluations conducted in the feasibility study. More detailed guidance on these assessments is provided in section 7.3.2.

The contamination assessment enumerated in the previous paragraph will be conducted for an enforcement-lead RI. Completion of this assessment, in conjunction with the public health and environmental evaluations in the feasibility study, will allow litigation teams to compare the results of these assessments with the endangerment assessment initially prepared to justify the enforcement action. This comparison will serve to refine or update the endangerment assessment to assure that a finding of imminent and substantial endangerment does, in fact, exist at the site. These three assessments then complete the endangerment assessment process performed during the RI/FS for an enforcement- lead site.

The results of site characterization efforts are quantitative and should permit determination of the doses that may be received by humans and the ecosystem. These dose rates can be compared to established criteria or to toxicological evidence to determine the risk associated with the exposure. This type of analysis is included in public health and environmental evaluation in the feasibility study.

The remedial investigation assessment is performed for the base case (no-action) scenario including future potential effects. RI assessments can also be conducted for specific purposes, such as (1) to allow cost and effectiveness information to be compiled on remedial action alternatives; (2) to limit further the number of remedial technologies for which data should be collected if additional site characterization is required to support the feasibility study; and (3) to support enforcement activities.

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7.2.6 Summary

Site characteristics determined during the remedial investigation are used to identify, screen, and develop appropriate remedial technologies and appropriate alternatives. As site characterization progresses, the need for further study must be evaluated on a continuing basis. This decision is based on the adequacy of the site characterization for evaluating potential remedial actions. Documentation should include the justification for additional study, specific data needs, and the recommended approach for collecting these data.

7.3 INVESTIGATION AND ASSESSMENT PROCEDURES NECESSARY FOR CHARACTERIZATION

The various site characterization activities should focus on conducting specialized types of investigations to collect the data required to determine the need for interim measures, and for preliminary analysis, screening, or final evaluation of remedial action alternatives. Characterization of sources, pathways, and receptors is the basis for determining the need for a remedial action.

This section provides guidance on the types of investigations and assessments appropriate for providing (via investigations) and evaluating (via assessments) the data needed to meet the site characterization requirements described in section 7.2.

7.3.1 Technical Investigations

Technical investigations focus on the characterization of waste sources, transport pathways, and receptors. These investigations can be categorized as studies of waste sources, geology, ground-water hydrology, surface-water hydrology, pedology, atmospherics, contaminants of concern, human populations, and ecology. The following section discusses the technical investigations required in each of these categories and concludes with a discussion of the use of models in site characterization.

7.3.1.1 Investigations of Source Characteristics

Source characterization involves the collection of data describing the physical and chemical aspects of the waste materials and the matrix in which they are contained. Relevant data can be grouped into three categories: (1) waste characteristics, such as the types and quantities of contaminants that may be contained in or released to the environment; (2) facility data that characterize how these contaminants may be released; and (3) site engineering characteristics that affect the implementation of remedial action alternatives. Key source characterization data are summarized in Table 7-1.

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TABLE 7-1. SUMMARY OF IMPORTANT SOURCE AND FACILITY INFORMATION

		Appropriate Collection Methods	
Information Needed	Purpose or Rationale	Primary	Secondary*
Waste Characteristics:			
• Type	Determine contaminants for exposure assessments and for treatment options	Site inspection, waste manifests	Sampling and analysis
• Form	Determine parameters for alternatives identity/ evaluation	Site inspection	Sampling and analysis, geophysical surveys
• Quantities	Determine magnitude of potential releases	Site inspection	Sampling and analysis, geophysical surveys
• Chemical and physical properties	Determine environmental mobility, persistence, and effects	Handbooks, CHEMTREC/OHMTADS, Chemical Information Service (CIS)	Laboratory analysis
• Concentrations	Determine quantities and concentrations potentially released to environmental pathways	Site inspection	Sampling and analysis
Facility Characteristics:			
• Type of waste/ chemical containment	Determine potential remedies for releases	Site inspection	Remote sensing

(continued)

*May be appropriate if detailed information is required.

TABLE 7-1. (continued)

		Appropriate Collection Methods	
Information Needed	Purpose or Rationale	Primary	Secondary*
• Integrity of waste/ chemical containment	Determine probability of release and timing of response	Site inspection	Sampling and analysis, nondestructive testing
• Drainage control	Determine probability of release to surface water	Site inspection, topographic maps	
• Engineered structures	Identify possible conduits for migration or interference with remedial actions	Site inspection	Remote sensing
• Site security	Determine potential for release by direct contact: may dictate response	Site inspection	
• Known discharge points (outfalls, stacks)	Provide points for accidental or intentional discharge	Site inspection	
• Mapping and surveying	Locate existing structures and obstructions for alternatives evaluation, site features, and topography	Existing maps (USGS, county, land development)	Remote sensing, surveying

*May be appropriate if detailed information is required.

Unless an extensively detailed, verifiable inventory of wastes at a site exists, it will be necessary to collect data on the types of contaminants, the location and volume (horizontal and vertical extent) of the sources, and the variation of concentrations within the source volume. This effort may require an extensive program involving discrete samples (or composites) over three dimensions and analysis using sophisticated techniques. Methods suitable for sampling and analysis are described in Ford, Turina, and Seely (1983).

It may be possible to determine the location and extent of sources and the variations of materials within a waste deposit by non-chemical analysis. Geophysical surveys, using a variety of techniques (e.g., ground-penetrating radar, electrical resistivity, electromagnetic induction, magnetometry, and seismic profiling), can effectively detect and map the location and extent of buried waste deposits. Aerial photography and infrared imagery can aid in defining sources through interpretation of the ecological impacts resulting from stressed biota. However, all of these geophysical methods are nonspecific, and subsequent extensive sampling of the sources may be required to provide the data for evaluation of source control measures at the site. The latter evaluations may also require field and laboratory measurements of soil porosity, permeability, and engineering characteristics.

The amount of each chemical that is buried in drums, spilled on/in surface soils, stored above ground, present in a lagoon, etc., should be determined. The integrity of chemical containment should also be determined; for example, it is important to know whether drums are leaking or likely to leak, or whether a lagoon is secure or is likely to overflow or leak into ground water. All of this information is necessary to estimate either qualitatively or quantitatively the level of contaminant release from the site. Pertinent contaminant-specific data include physical/chemical properties of the target chemicals, which can be obtained from standard chemical reference sources, such as Weast (1971); Perry and Chilton (1973); Windholz (1976); Aldrich Chemical Company (1980); Verschueren (1977); Hansch and Leo (1979); Dawson, English, and Petty (1980); Lyman, Reehl, and Rosenblatt (1981); Hawley (1981); Kirk-Othmer (1978); Callahan et al., (1979); and Mabey, Smith, and Podoll (1982). The information is also available from the Chemical Information Service (CIS) and other commercial computerized data bases.

Obtaining and organizing all of these data constitute the first steps of the site investigation. Because all subsequent analyses will focus on the chemicals identified at this stage, great care should be taken to ensure that no significant chemicals or release sources are overlooked.

7.3.1.2 Geologic Investigations

The geology of the area is important in site evaluation because of the interrelationships between geology and source releases, water movement and contaminant transport, and ease of implementation of remedial alternatives. Structures influencing ground-water flow may include folds, faults, joints, fractures, and interconnected voids. Stratigraphic information may be used to identify aquifers and confining formations so that the units most likely to

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transport contaminants can be delineated. Stratigraphic data and composition of the geologic units are useful in estimating effective porosity, permeability, and homogeneity, which cause flow within an aquifer. The geologic information that may be needed to evaluate the site hydrology and site engineering aspects is summarized in Table 7-2.

7.3.1.3 Ground-Water Investigations

Ground-water contamination can result from surface spills, seepage from injection wells, mass dumping into pits, and leaching from buried wastes or lagoons. Characterization of contaminant transport in ground water requires that the hydrologic properties of the aquifer be determined. The direction of ground-water flow can be determined by comparing static water level elevations in a series of wells completed in the same aquifer. The flow rate can be calculated from the gradient of the ground-water surface, and hydraulic conductivity and porosity. The rate can be determined more precisely from the results of pumping tests. Flow varies according to aquifer type (confined, unconfined, or perched), hydrologic boundaries, interconnection with other aquifers (leakage), and hydrologic stresses (recharge or withdrawal).

Ground-water and geologic data not available in the literature almost always require direct observation through the installation of ground-water wells, aquifer tests to determine flow parameters such as permeability and hydraulic potential, and extensive sampling and analysis. Geophysical survey methods may be useful for determining geologic and geohydrologic conditions and for evaluating the direction and extent of contaminant plumes. Procedures for well installation, aquifer testing, and sampling of the ground-water regime are described in Ford, Turina, and Seely (1983). The types of hydrologic data that may be needed to characterize the movement of contaminants in ground water are presented in Table 7-3.

7.3.1.4 Surface-Water Investigations

If contaminants can be transported via surface-water runoff, then sampling to evaluate the types and levels of contaminants within these media should be performed. Because the importance of these pathways depends greatly on weather conditions, data should be collected at specific, known locations (or stations), under known meteorological conditions, and through periods representing natural cycles in ambient conditions. For example, surface-water samples might be collected at an established station over a seasonal or annual hydrologic cycle and before, during, and after periods of heavy rainfall. Extensive sampling and chemical analyses may be required. Established sampling and analytical procedures for surface-water field studies can be found in Ford, Turina, and Seely (1983 and 1984) and in U.S. EPA (1982c and 1984k).

TABLE 7-2. SUMMARY OF IMPORTANT GEOLOGIC INFORMATION

		Appropriate Collection Methods	
Information Needed	Purpose or Rationale	Primary	Secondary*
Structural Features:			
• Folds, faults	Determine natural flow barriers or controls	Existing geologic maps, field surveys	Remote sensing, aerial photography, geophysical techniques
• Joints, fractures, interconnected voids	Predict major boundaries, avenues of ground-water flow	Existing geologic profiles, pump tests	Borehole logging and mapping, geophysical techniques (limited)
Stratigraphic Characteristics:			
• Thickness, aerial extent, correlation of units, extent (horizontal and vertical) of aquifers and confining units	Determine geometry of aquifers and confining layers, aquifer recharge and discharge	Existing geologic maps, observation wells	Borehole logging and mapping, geophysical techniques (limited)
• Mineral composition, permeability and porosity, grain-size distribution, in-situ density, moisture content	Determine ground-water quality, movement, occurrence, productivity	Laboratory analysis, existing geologic literature	Existing literature

*May be appropriate if detailed information is required.

TABLE 7-3. SUMMARY OF IMPORTANT GROUND-WATER INFORMATION

		Appropriate Collection Methods	
Information Needed	Purpose or Rationale	Primary	Secondary*
Ground-Water Occurrence:			
• Aquifer boundaries and locations	Define flow limits and degree of aquifer confinement	Existing literature, Water Resource Atlases	Borehole logging, regional water level measurements
• Aquifer ability to transmit water	Determine potential quantities and rates for treatment options	Pumping and injection tests of monitor wells	
Ground-Water Movement:			
• Direction of flow	Identify most likely pathways of contaminant migration	Existing hydrologic literature	Water level measurements in monitor wells
• Rate of flow	Determine maximum potential migration rate and dispersion of contaminants	Existing hydrologic literature	Hydraulic gradient, permeability, and effective porosity from water level contours, pump test results, and laboratory analyses
Ground-Water Recharge/Discharge:			
• Location of recharge/discharge areas	Determine interception points for withdrawal options or areas of capping	Existing site data, hydrologic literature, site inspection	Comparison of water levels in observation wells, piezometers, lakes and streams

(continued)

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*May be appropriate if detailed information is required or if it is the only method due to a paucity of published data.

TABLE 7-3. (continued)

		Appropriate Collection Methods	
Information Needed	Purpose or Rationale	Primary	Secondary*
• Rate	Determine variability of loading to treatment options	Existing literature	Water balance calculations aided by geology and soil data
Ground-Water Quality:			
• pH, total dissolved solids, salinity, specific contaminant concentrations	Determine exposure via ground water; define contaminant plume for evaluation of interception methods	Existing site data	Analysis of ground-water samples from observation wells, geophysics

*May be appropriate if detailed information is required or if it is the only method due to a paucity of published data.

The transport of a contaminant in surface water is controlled by the flow, which in streams is a function of the gradient, geometry, and coefficient of friction. The contaminant has three possible modes of transport: (1) it may be sorbed onto the sediment carried by the flow; (2) it may be carried as a suspended solid; or (3) it may be carried as a solute (dissolved). Solute transport is the fastest mode of transport. The transport of a dissolved contaminant can be determined by characterizing the flow of the surface water and the contaminant dispersion, whereas sediment and suspended solid transport include other processes such as deposition and resuspension. It is also important to consider possible interactions between surface water and ground water. The surface-water information that may be required for remedial investigations is presented in Table 7-4.

7.3.1.5 Pedological Investigations

The amount of contaminated liquid that infiltrates into the ground depends on the ground cover, antecedent moisture, land use, and the surface soil type. The amount of contaminated liquid and the pathway it may take to enter an aquifer depend on the physical properties (e.g., permeability, porosity) of the subsurface geologic media and the near-surface characteristics (e.g., soil porosity and moisture content, slope, vegetative cover).

Wet soils are resistant to percolation, steeper slopes have greater runoff, and low permeability clay or silt lenses may deflect contaminant migration horizontally. A dissolved contaminant can infiltrate with the water, whereas contaminants that are suspended or sorbed onto sediments may remain. Rainfall or flooding may result in sudden transport, although the contaminant would be diluted. Transport of the contaminant can be determined by soil samples taken at varying depths and distances from the source.

Soil chemistry plays a major role in the transport of chemicals through the soil and in the availability of the chemicals for biological uptake. Both physical processes (e.g., adsorption/desorption) and chemical processes within the soils (e.g., complexation of metals by soil constituents) should be investigated in characterizing the migration of contaminants through soils. The species present and the leachability of chemicals from the soil must be determined to understand potential biological uptake. Table 7-5 summarizes characteristics of the unsaturated zone and soil properties that should be identified.

Appropriate methods for collecting geochemical data include sampling/analysis through the soil column, (e.g., using lysimeters) and adsorption/desorption experiments. Existing geochemical transport models require an extensive array of data which may be beyond the scope of site characterization efforts. Experts in geochemistry and pedology should be consulted to define appropriate procedures if site conditions warrant investigations beyond providing chemical data within soil profiles.

TABLE 7-4. SUMMARY OF IMPORTANT SURFACE-WATER INFORMATION

		Appropriate Collection Methods	
Information Needed	Purpose or Rationale	Primary	Secondary*
Drainage Patterns:			
• Overland flow, topography, channel flow pattern, tributary relationships	Determine if overland or channel flow can result in onsite or offsite flow and if patterns form contaminant pathways	Topographic maps, site inspection	Aerial mapping, ground survey
Surface-Water Bodies:			
• Flow, stream widths and depths, channel elevations, flooding tendencies	Determine volume and velocity, transport times, dilution potential, potential spread of contamination	Public agency data and atlases; catalogs, maps, and handbooks for background data	Aerial mapping, ground survey
• Structures	Effect of man-made structures on contaminant transport and mitigation	Public agency maps and records	
• Surface-water/groundwater relationships	Predict contaminant pathways for interceptive remedial actions	Public agency reports and surveys	Water level measurements, modeling
Surface-Water Quality:			
• pH, temperature, total suspended solids, suspended sediment, salinity, specific contaminant concentrations	Provide capacity of water to carry contaminants and water/sediment partitioning	Public agency computerized data files, handbooks, open literature	Sampling and analysis

*May be appropriate if detailed information is required.

TABLE 7-5. SUMMARY OF IMPORTANT PEDOLOGICAL INFORMATION

		Appropriate Collection Methods	
Information Needed	Purpose or Rationale	Primary	Secondary*
Soil Characteristics:			
• Type, holding capacity, temperature, biological activity, engineering properties	Estimate the effect of the properties on infiltration and retardation of leachates and the release of gaseous contaminants	Reports and maps by Federal and county agencies, Soil Conservation Service (SCS) publications	Borehole sampling, laboratory measurements (ASTM methods)
Unsaturated Zone Characteristics:			
• Permeability, variability, porosity, moisture content, chemical characteristics, extent of contamination	Estimate leachate transport through soil matrices	Existing literature	Borehole logs, geophysical surveys, sampling and analysis, lysimeters
Soil Chemistry Characteristics:			
• Solubility, ion speciation, adsorption coefficients, leachability, exchange capacity, mineral partition coefficients, chemical and sorptive properties	Predict contaminant movement through soils and availability of contaminants to biological systems	Existing scientific literature	Chemical analysis, column experiments, leaching tests

*May be appropriate if detailed information is required.

7.3.1.6 Atmospheric Investigations

Airborne contaminants can be released by fire, explosion, evaporation, sublimation, and industrial processes. Data on the characteristics of the release and the atmospheric conditions may be required to define the path and dispersion of the release. Atmospheric conditions can also cause transport by other pathways; for example, precipitation can result in transport by both surface water and ground water. Climatic data can be obtained from the U.S. Department of Commerce (1961 and 1968). The design and implementation of air sampling systems are discussed in U.S. EPA (1971a) and ASTM (1974). Table 7-6 summarizes atmospheric investigations that may be needed at a site.

7.3.1.7 Identification of Contaminants of Concern

Before any analysis of the potential for human or environmental exposure can begin, those chemicals on which the analyses will focus must be selected. Relatively few chemicals should be selected for analysis for any site; however, any chemicals for which environmental standards or criteria have been developed should be included in remedial investigation analyses. Detailed guidance for selecting target chemicals will be presented in the forthcoming Superfund public health evaluation guidance.

The goal of chemical selection is to choose chemicals that represent the most hazardous chemical species or families present at the site, in terms of prevalence, toxicity, and mobility. Selection is based on hazard-related criteria, which must be defined during the remedial investigation. Because a toxic substance does no harm to human health until exposure occurs, the likelihood of the migration of the chemical from the site is a major consideration in chemical selection. The following six factors relating to the migration and exposure potential of a given chemical must be determined:

- Amount of each chemical present at the site
- Evidence of existing or past environmental contamination
- Volatility
- Mobility in soil
- Solubility in water
- Transformation potential.

7.3.1.8 Investigations of Affects on Public Health

To assess public health impacts two broad categories of data should be collected during the remedial investigation: first, data to evaluate the

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TABLE 7-6. SUMMARY OF IMPORTANT ATMOSPHERIC INFORMATION

		Appropriate Collection Methods	
Information Needed	Purpose or Rationale	Primary	Secondary*
Local Climate: • Precipitation • Temperature • Wind speed and direction • Presence of inversion layers	Define recharge, aeolian erosion, evaporation potential, effect of weather patterns on remedial actions, area of deposition of particulates	National Climate Center (NCC) of National Oceanic Atmospheric Administration, local weather bureaus	Onsite measurements and observations
Weather Extremes: • Storms • Floods • Winds	Determine effect of weather extremes on selection and timing of remedial actions, extremes of depositional areas	NCC, State emergency planning offices	
Release Characteristics: • Direction and speed of plume movement • Rate, amount, temperature of release • Contaminant concentrations • Relative densities	Determine dispersion characteristics of release	Information from source facility, weather services, air monitoring services	Onsite measurements

*May be appropriate if detailed information is required.

likelihood of contaminant release from the site and to predict the environmental fate of released substances, and second, information to identify, enumerate, and characterize human populations exposed to toxics escaping from the subject site.

Much of the data in the first category will be obtained and organized when selecting chemicals of concern (see section 7.3.1.7). Various site hydrologic, climatologic, physiographic, and operational parameters are also needed (see previous tables). Additionally, the assessment of the biochemical fate of released contaminants may require information on the geographic locations of elevated concentrations, biomagnification potential of the chemicals involved, biotic populations around sites, biologic behavior patterns, inter-species ecological relationships, and the interaction between biota and humans. Sampling and site observations should support any modeling activity anticipated. These data are generated through site investigation and contact with local, State, and national wildlife management agencies, census bureaus, outdoor recreation groups, and agricultural authorities.

The second category of data, obtainable from maps and Bureau of the Census reports, includes the numbers and locations of inhabitants in a given geographic area. Data describing the type and extent of human contact with contaminated media are also needed. This information generally includes:

- Local use of surface waters draining the site
  - Drinking water
  - Recreation (swimming, fishing)

- Local use of ground water as a drinking water source
  - Distance of wells from site
  - Expected direction of ground-water flow

- Human use of or access to the site and adjacent lands
  - Recreation
  - Hunting
  - Residential
  - Commercial
  - Relationship between population locations and prevailing wind direction.

When mutagenic or teratogenic chemicals are involved, the population age and sex distribution of the population may be needed to identify high-risk subpopulations. Also, any existing epidemiological data concerning affects already shown by populations near the subject site are helpful. These data may include direct evidence of health impact (e.g., increased morbidity and mortality) or evidence of potential health impacts (e.g., body burden measurements for contaminants of concern). Potential health impacts can be characterized using EPA guidelines being developed for exposure assessments, carcinogenicity, mutogenicity, teratogenicity and fetotoxic endpoints, and for exposure to chemical mixtures and systemic toxicants (U.S. EPA 1984f-1984k).

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7.3.1.9 Biological/Ecological Investigations

Biological and ecological information is collected for use in the endangerment and environmental assessments. The assessment should follow the guidelines of the National Environmental Policy Act of 1969, as amended; however, State guidelines may be more stringent and should also be consulted. The information should include identification of the site fauna and flora (especially endangered species and those consumed by humans or found in human foodchains), critical habitats, land use, water use, and the distribution of water wells (U.S. EPA, 1982b). Special consideration should be given to environmental characteristics studied in the remedial investigation, and any public health and environmental assessments performed for the feasibility study demand special attention; for example, waste components that become incorporated into potential human food stuffs through the environmental pathway should be considered.

A summary of required environmental information is provided in Table 7-7. Most of this information should be available in public records. Environmental population characteristics and information on land use can be found on local or regional maps.

7.3.1.10 Use of Models in Site Investigation

Models can be valuable to a remedial investigation by (1) improving the conceptual understanding of contaminant migration; (2) predicting the impact of remedial actions or natural processes; and (3) estimating chemical releases and migration over time, leading to estimates of exposure to humans and/or the environment. The latter two uses are directly relevant to assessments made during the feasibility study. Models provide a means of testing (and confirming) assumptions about the location of sources and the relative importance of different environmental pathways and processes. Modeling can also be used to define future sampling requirements by identifying inconsistencies and uncertainties in existing data.

Models applicable to site characterization, exposure assessment, and remedial action assessment can be grouped according to their relative accuracy and their ability to depict site conditions. Simplified models (e.g., analytical and semi-analytical models) quantitatively estimate site conditions with relatively low accuracy and resolution. Typically, they provide order-of-magnitude estimates (U.S. EPA, 1982a) and require that simplifying assumptions be made regarding site conditions and chemical characteristics. They are useful for screening alternative remedial actions and may also be used for detailed analysis of alternatives.

Simplified models can be well suited to site investigations. Reviews of simplified models include a comprehensive discussion of simple models of surface-water contaminant transport and fate by Mills et al. (1982), two handbooks on analytical ground-water models by Walton (1983a and 1983b), a

TABLE 7-7. SUMMARY OF IMPORTANT ENVIRONMENTAL INFORMATION

		Appropriate Collection Methods	
Information Needed	Purpose or Rationale	Primary	Secondary*
Fauna and Flora	Determine potentially affected ecosystems; determine presence of endangered species	Public records of area plants and animals survey, survey of plants and animals on or near site, survey of site/area photographs	Remote sensing, ground survey
Critical Habitats	Determine areas on or near site to be protected during remediation	Public records of site environment	Ground survey
Land Use Characteristics	Determine if terrestrial environment could result in human utilization, e.g., presence of game animals, agricultural land	Agricultural and development maps, site survey	Remote sensing, ground and aerial survey
Water Use Characteristics	Determine if aquatic environment could result in human utilization of water, e.g., presence of game, fish, recreational waters	Water resource agency reports, site survey	
Biocontamination	Determine observable impact of contaminants on ecosystems		Sampling and analysis, remote sensing

*May be appropriate if detailed information is required.

paper on subsurface drain modeling by Cohen and Miller (1983), an inventory of analytical solutions to ground-water contaminant transport problems by van Genuchten and Alves (1982), and a comprehensive review of simplified methods for representing remedial actions by Brown (1983).

More detailed mathematical models (e.g., numerical computer codes) provide greater accuracy and resolution (U.S. EPA, 1982a) because they are capable of representing spatial variations in site characteristics and irregular geometries commonly found at actual sites. These models can also represent the actual configuration and effects of remedial actions on site conditions. Detailed mathematical models are sometimes appropriate for investigations where detailed information on contaminant transport and fate is required. Mercer and Faust (1981) provide an overview of ground-water modeling, while Thomas, Ross, and Mercer (1982) review numerical ground-water flow and transport models. Orlob (1971) discusses mathematical modeling of estuaries. Donigian (1981) reviews runoff and instream contaminant transport and fate models. Oster (1982) addresses flow and transport in the unsaturated zone, and Onishi et al. (1981) review sediment transport and water quality mathematical models.

Deciding whether models should be used and selecting appropriate models for the remedial investigation can be difficult. Modeling may not be needed if site conditions are well understood and the potential effectiveness of different remedial actions can be easily evaluated. Even at more complex sites, mathematical modeling may not be justified if resources (e.g., data and expertise) are limited or relatively straightforward remedial actions are expected to be used. When modeling is potentially appropriate, selection of the model must consider:

- Data requirements
- Ability to resolve key variations in site conditions and the physical configuration of remedial actions
- The dimensionality of the flow field
- Ability to represent key physical and chemical processes
- Cost and time frame for applying, verifying, and using the model as a predictive tool
- Required knowledge and experience of the model user.

Boutwell (1984) presents a methodology designed to help determine: (1) whether modeling should be considered; (2) if so, what type is the most appropriate; and (3) the specific capabilities that the model(s) should have. Thomas, Ross, and Mercer (1982) discuss the selection and use of models in repository siting studies, and U.S. EPA (1983c) provides guidance on the selection of models for exposure assessment.

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In selecting and applying models, it is important to remember that a model is an artificial representation of a physical system and is only an alternative way of characterizing and assessing a site. A model cannot replace field data, nor can it be more accurate than the available site data.

Model selection should be addressed early in the RI planning. Models have specific information needs that must be satisfied; otherwise their results may be meaningless. If the specific information needed requires the collection of samples, such information should be included in the sampling plan.

The goals of the site characterization are to specify, at least roughly, the current extent of contamination and to estimate the travel time to and approximate chemical concentrations at exposure sites. While field data generally best define the extent of contamination, models can interpolate among and extrapolate from isolated field samples and interpret field data so as to create a more detailed description. Models can aid the data reduction process by providing the user with a structure for organizing and manipulating field data.

Use of models requires special expertise. Time and experience are needed to select the appropriate code and subsequent calibration. If these resources are not available, modeling should not be attempted. Models are used in conjunction with scientific and engineering judgment; they are an aid to, not a surrogate for, a skilled analyst.

7.3.2 Assessment Procedures

Data collected from various investigation activities must be evaluated and assessed. The purposes of these assessments are to determine whether the data collected meet the objectives and to present data and interpretations in formats useful for making decisions about subsequent work during the feasibility study.

7.3.2.1 Contamination Assessment

The contamination assessment, a necessary initial part of public health and environmental assessments, determines the severity of hazards by considering the quantities and types of contaminants at and around the site and transport mechanisms that are allowing or may allow migration of contaminants from the site. The quantities, types, forms, and concentrations of contaminants at a site and in surrounding environmental media should be described. A quantitative evaluation of observed and potential migration of contaminants should be provided. The contamination data and assessment

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provide input to two questions that should be answered as early as possible in the feasibility study or as part of the RI:

- Are there hazardous substances at a site of such types and in such quantities that a remedial action or further study is warranted?
- Are hazardous substances migrating or is there significant potential for them to migrate through environmental pathways in such magnitude or at such a rate that a remedial action or further study is required?

The assessment consists of a succinct presentation and analysis of the source and pathways data that have been collected, including:

- A description of the environmental setting at a site, including important geologic, hydrologic, and atmospheric data and determinations. These data should be presented in the form of contour maps illustrating important features of potential migration pathways and other information of use for evaluating remedial alternatives.
- A description of the hazardous substances found, including types, quantities, forms, and degrees of containment. Appropriate regulatory standards or criteria and analytical detection limits should also be described.
- A description of contaminant concentration levels found in environmental media at and near the site. Concentration contour maps should be provided in a format directly comparable with the pathways data.
- A summary of findings most relevant to the objectives of site characterization and to the evaluation of remedial action alternatives.
- Supporting appendices of all data.

7.3.2.2 Public Health Assessment

The public health assessment is conducted during the feasibility study; however, the remedial investigation must provide data for the assessment. Broadly speaking, the data should be adequate to answer four basic questions regarding the evaluation of human population exposure and risk associated with hazardous waste sites:

- To what chemicals are populations potentially exposed?
- What are the size and distribution of potentially exposed populations?

- What is the concentration of each chemical to which populations are exposed?

- How does exposure occur?

These questions can be addressed by analyses of the type and amount of chemicals released from the site, the environmental fate of chemicals migrating from the site, and the points at which human populations are likely to contact contaminants in environmental media. The assessment itself can be qualitative or quantitative, depending on the availability of required data, the depth of analysis required, and the nature of the problem.

Qualitative human population exposure analyses can be based on existing information. The one exception to this is the evaluation of the release potential of selected contaminants of concern. Because release depends largely on the physical/chemical properties of a substance, chemical-specific data addressing volatility, solubility in water, and adsorption potential must be obtained.

The goal of a qualitative analysis is not to quantify the extent of human exposure and associated risk but (1) to understand how the chemicals migrate from the site and reach points of contact with local populations, and (2) to define the potentially exposed populations in general terms.

To evaluate potential human exposure, it is important to consider the amounts of chemicals present and the manner of their placement at the site (e.g., buried in drums, spilled in lagoons). The potential for release of each contaminant of concern from each on-site source to various environmental media must be evaluated separately. Table 7-1 summarizes pertinent release sources for which data should be obtained and evaluated in a qualitative assessment.

Following assessment of the release of hazardous substances from the site, the potential for migration of these substances in each environmental media beyond site boundaries is considered. If available, environmental monitoring results can provide a direct measure of migration potential. Alternatively, a qualitative fate evaluation may be done using data on the physical/chemical properties of each target substance and pertinent site and biologic parameters.

After the environmental fate analysis has determined the general locations of potentially contaminated media (or the monitoring data have identified actually contaminated media), exposed-population analysis is conducted to determine which populations are likely to be exposed through contact with these media. Human population information required for this analysis is very general, although it must include all potential points of exposure. Integrated exposure analysis combines various medium-specific exposures (e.g., via food, inhalation) to assess overall exposure to contaminants migrating from the site.

If relevant epidemiological data are available, they can provide valuable evidence of the actual type and severity of health risk posed by the site. However, care must be taken in interpreting epidemiological data when a site is located near other sources of the same contaminants (or other contaminants with similar health effects). It may be difficult or impossible to determine the cause of observed health effects in these situations.

In a quantitative approach to public health assessment, the supporting data must be adequate to permit quantitative estimates of hazardous substance release, ambient concentrations in environmental media beyond site boundaries, and population exposure. The objectives of this analysis are two-fold: (1) to generate a most probable case, conservative quantification of maximum and average exposure at all identified human exposure points of potential significance, and (2) to calculate the reduction in population exposures achievable by various remedial technologies. Meeting this second objective supplies the human-exposure-related input to the screening of remedial technologies and development of alternatives. Although the quantitative approach is more detailed than the qualitative, it is still primarily designed to generate estimates. Guidance on when to use qualitative and quantitative analysis is included in the public health evaluations chapter in the feasibility study guidance.

It may be necessary to support assessments by acquiring additional data on specific contaminant sources via a more targeted site inventory (field measurements or source monitoring). Also, because risk analysis for public health addresses both chronic and subchronic risk, these data must be sufficient to allow generation of an average (averaged over an assumed 70-year lifetime) and a maximum (usually 7 days) release estimate (U.S. EPA, 1985b). Additional field monitoring may be necessary to quantify environmental concentrations of the contaminants.

Environmental standards or criteria that pertain to the contaminants should be reviewed. When available, these are compared with contaminant concentrations in environmental media to indicate the extent of risk when humans come into contact with these environmental concentrations. Sources of such information include EPA CASR and computerized information for Dialog File, Chemical Regulations Guidelines System, and the Bureau of National Affairs' (BNA) Chemlaw (see OTS Information Architecture Handbook).

7.3.2.3 Environmental Assessment

The environmental assessment, like the public health assessment, is conducted during the feasibility study. The remedial investigation must provide data to conduct an evaluation of the effects on the environment at or near a hazardous waste site. Similar to the public health assessment, the

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environmental assessment should answer four questions (U.S. EPA, 1983d; U.S. EPA, 1983c):

- What chemicals have been or might be released to the environment?
- What are the concentrations and exposure levels of these chemicals?
- How does the environmental exposure occur?
- What is the significance?

The environmental assessment, conducted in the feasibility study, may require data to complete the five analytical steps shown in Figure 7-2:

- Characterize source
- Determine fate
- Identify populations at risk
- Calculate dose
- Assess impacts.

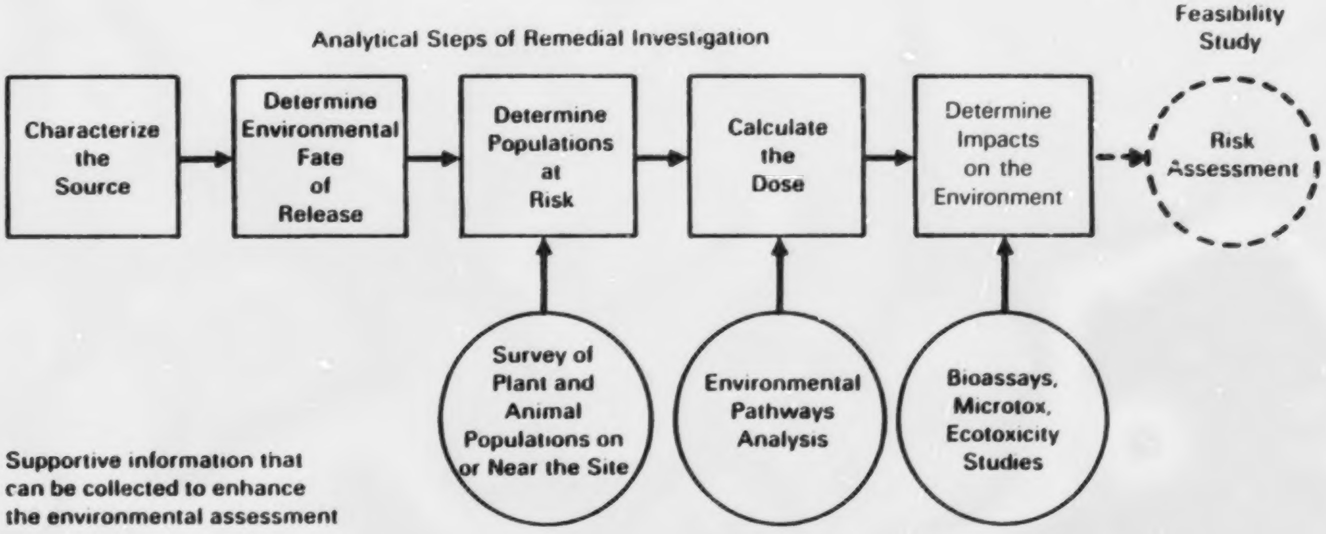
Quantification of the source of release is a site characterization task that is common to all the exposure assessments in the remedial investigation. The chemical and physical properties of the source and additional site characteristics that affect the environmental fate of the source must be known to complete the environmental assessment.

The fate of the contaminants in the environment is critical to the conclusions of the environmental assessment. It is important to know where contaminants can enter the environment and what environmental media (water, air, soil) will receive or transmit the contaminants (pathways). It is also important to identify those contaminants that will be transformed. Specifically, the assessor should determine which chemicals will be found in areas on or near the site that are used by plants and animals.

In a related step, it is necessary to identify the plant and animal populations that will be in direct or indirect contact with the chemicals. Because extensive plant and animal population surveys can be expensive, data collection criteria should be established to ensure the most cost-effective survey. Of particular importance are threatened or endangered species, species that are consumed by man, species in the food chain up to humans, or species of local or regional importance. This information may also be important to the assessment of human health exposure, so data collection should be designed to fulfill both needs.

Before the environmental assessments can be completed, the dose to important environmental populations should be calculated. Dose calculations

Figure 7-2. Supportive Information for Environmental Assessment


Analytical Steps of Remedial Investigation
Feasibility Study
Characterize the Source
Determine Environmental Fate of Release
Determine Populations at Risk
Calculate the Dose
Determine Impacts on the Environment
Risk Assessment
Survey of Plant and Animal Populations on or Near the Site
Environmental Pathways Analysis
Bioassays, Microtox, Ecotoxicity Studies
Supportive information that can be collected to enhance the environmental assessment

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should consider environmental concentrations and the potential duration of the exposure. This task parallels the dose calculation analysis that is necessary for the public health assessment. For consistency, similar dose determination techniques or methods should be applied.

Based on the environmental population studies, it should be possible to focus the detailed analysis of impact on potentially affected species. Ultimately, it may be necessary to collect detailed information about a population or species. Life history data (breeding, spawning, or flowering seasons; migration and dispersion patterns; and feeding and nutrient requirements) may be needed to define further the populations (Porcella, 1983).

The calculations of dose may require additional environmental details. The species tolerances to the chemical(s) in the environment should be determined, which may require bioassays, microtox analysis, and detailed biological sampling of the site environment. In addition, responses to potential degradation products may also need to be addressed. These detailed and complex procedures illustrate the potential extent of an environmental assessment.

Guidance on performing environmental assessments is discussed in chapter 6 of the feasibility study guidance.

7.4 PROGRAMMATIC FACTORS AFFECTING SITE CHARACTERIZATION ACTIVITIES

Several constraints on site characterization influence the way in which the program is conducted. These include connections with potential enforcement actions under CERCLA, the desire to minimize program costs within the "necessary and sufficient" philosophy, the necessity of ensuring data quality, and timing and scheduling concerns.

7.4.1 Responsible Party Actions

The U.S. EPA has established the policy of giving responsible parties the opportunity to conduct site characterization, as well as remedial response activities, under the NCP, subpart F, sections 300.68(c) and 300.68(f), according to approved plans for remedial investigations/feasibility studies. Because site characterization activities can be scoped (see chapter 2), planned, and conducted by the responsible parties, there is an obvious need for adequate supervision and for a system of proven document control (see chapter 4).

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Any previous, concurrent, or subsequent investigations and data provided by potential responsible parties should be scrutinized closely in formulating site characterization studies. Questions to ask in screening such information include:

- Is documentation adequate for evidentiary purposes?
- Were quality assurance/quality control procedures established and implemented?
- Were standard data collection and assessment methodologies used?
- Were the site characterization efforts objective?

Deficiencies that exist in the information supplied by responsible parties should be considered when planning subsequent site activities.

7.4.2 Documentation and Recordkeeping

Stringent demands for proper documentation and recordkeeping exist throughout the remedial investigation (see chapter 4). These requirements are most important during site characterization because these activities generate the basic data used in making all subsequent decisions. Establishing, maintaining, and safeguarding data and records according to the principles discussed in chapter 4 should be an integral part of the site characterization process. These procedures include establishing document control with particular emphasis on enforcement-sensitive materials.

7.4.3 Timing and Scheduling Concerns

The timing and scheduling requirements of site characterization activities are important. Inputs and outputs of the various characterization activities are connected to other investigative activities within the overall remedial investigation/feasibility study timeline. In addition to the overall need to conduct the remedial investigation quickly and efficiently and proceed, if necessary, with response actions, such interconnections must be considered during the site characterization planning process. The time required for each activity (e.g., data collection, assessment, documentation) varies according to the level of resolution required and also depends on external factors such as weather, funding mechanisms, the site priority, and the status of any legal action. Probable schedules for each site activity are established during the scoping exercises (chapter 2) and must be re-evaluated once site characterization begins. If adjustments to the overall remedial investigation/feasibility study are required, they must be coordinated with all parties concerned.

CHAPTER 8

BENCH AND PILOT STUDIES

8.1 INTRODUCTION

Bench and pilot studies may be needed to obtain enough data to select and implement a remedial action alternative. Justification for these studies is found in section 300.68 of the National Contingency Plan (NCP). This chapter addresses ways bench and pilot studies are used in remedial investigations and presents guidance for:

- Determining the need for bench and pilot studies based on the site/waste characteristics or technology
- Developing a test plan by defining the goals and level of study needed
- Interpreting and applying data developed during the study.

Hazardous waste site remediation programs have challenged technologies in two principal ways. First, both traditional and emerging technologies from many different disciplines are being applied on an accelerated and often overlapping basis. Technologies from the materials and soils science fields, critical to the containment strategies being used, evolved in relatively clean environments. As a result, there is little information about technology performance in a contaminated environment (i.e., how a synthetic or clay liner will behave at a waste site). Second, the treatment technologies developed for industrial wastes depend on an aqueous environment to facilitate the transfer and conversion of pollutants and removal of byproducts. In the typical remedial problem, mass transfer is usually a critical or rate limiting factor.

Almost without exception, the following conditions will apply in a hazardous site remediation project:

- The physical matrix in which a technology must work is heterogeneous; that is, solid, slurry, aqueous, or gaseous environments can exist all within a given setting.

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- The hazardous constituents are (usually) as heterogeneous as the matrix.

As a result of these circumstances, the transferability of a technology is limited not only by the discipline or science in which the technology originated but also from one hazardous waste site to the next. All too often the limits of technology transferability have been ignored or inadequately considered, and the penalties have been expensive; liner failures, ineffective treatment systems, and underground gas migration are frequent examples. Bench and pilot studies are alternatives to haphazard transfer of technology from one application to another (with attendant risks of time, dollar, and resource losses).

8.2 OVERVIEW OF BENCH AND PILOT STUDIES

As shown in Figures 1-2 and 8-1 (RI/FS process diagrams), bench and pilot studies, if needed to support remedial alternatives development and feasibility analyses, are conducted as part of the remedial investigation task sequence. However, bench and pilot studies may also be conducted for design and construction of the selected alternative and are outside the scope of RI/FS activities. In general, bench-scale studies are appropriate for the remedial investigation stage, while pilot-scale studies, if required, may be conducted during the final design. The scope of bench and pilot activities during the RI is generally limited to treatability and materials testing activities to help identify, screen, and evaluate FS alternatives.

During the initial tasks of the FS, treatment alternatives are developed and then screened later in the process. Information from these tasks and the analysis of information from the site investigation are used to identify information gaps and to establish the need for bench and pilot studies. An appropriate experimental plan is then developed and documented in a Statement of Work (SOW). The results are used in the technical analysis for screening and analyzing remedial alternatives in the feasibility study as well as developing the design for the selected alternative.

8.2.1 Difference between Bench and Pilot Studies

Bench studies differ from pilot studies in purpose, size, cost, application, and other factors, which are summarized in Table 8-1. Their purpose is to determine the feasibility of an application over the range of conditions expected. Bench-scale studies are flexible in that a wide range of variables can be evaluated in determining the performance capabilities and limitations of a technology.

Pilot studies may be used in the RI to guide the selection of an alternative when the choice cannot be made from bench-scale data, or they may

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Figure 8-1. Bench/Pilot Study Logic Diagram

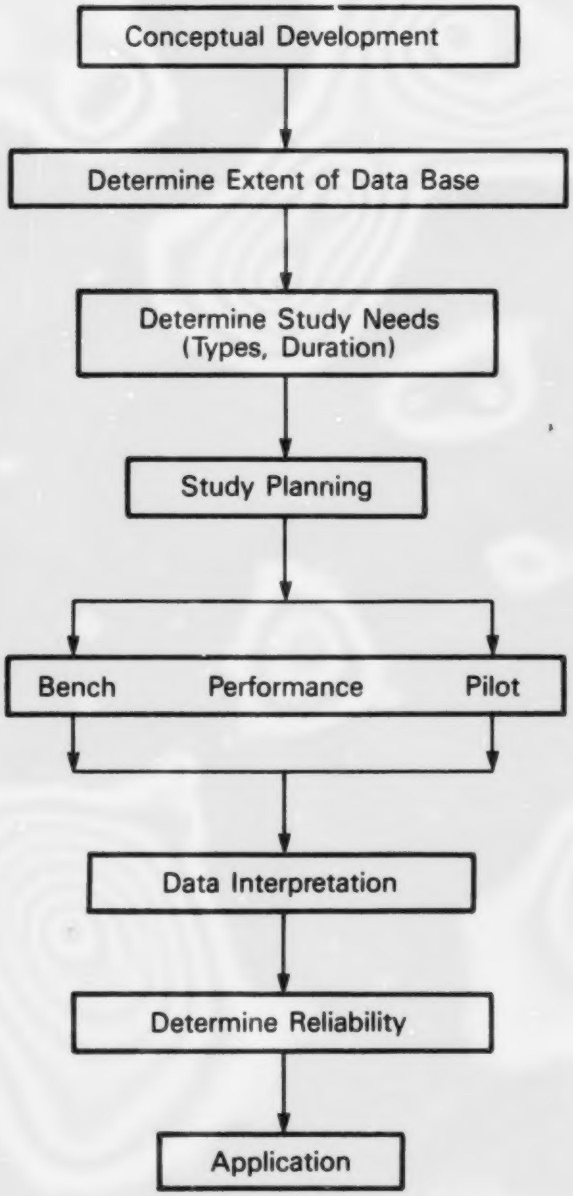
Conceptual Development
Determine Extent of Data Base
Determine Study Needs (Types, Duration)
Study Planning
Bench
Performance
Pilot
Data Interpretation
Determine Reliability
Application

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TABLE 8-1. BENCH AND PILOT STUDY PARAMETERS

Parameter	Bench	Pilot
Purpose	Define process kinetics, material compatibility, impact of environmental factors, types and doses of chemicals, active mechanisms, etc.	Define design and operation criteria, materials of construction, ease of material handling and construction, etc.
Size	Laboratory or bench top	1-100% of full-scale
Quantity of Waste and Materials Required	Limited amounts	Large amounts
Number of Variables That Can Be Considered	Many	Few
Time Requirements	Days to months	Months to years
Typical Cost Range	0.5-2% of capital costs	2-5% of capital costs
Most Frequent Location	Laboratory	On-site
Limiting Considerations	Wall and boundary effects; volume effects; solids processing difficult to simulate	Limited number of variables; waste volume required; safety, health, and other risks

be used outside the RI/FS process to define the design and operating criteria and specific features of a selected alternative. Pilot studies are also useful in determining the stability of a process or material in an application and are aimed at delineating specific design and operating criteria. These studies are much larger than bench studies in scale, cost, time, and waste volume required.

8.2.2 Approach

The specific need for bench and pilot studies may be identified during the RI/FS process or during remedial alternative design. The need is defined from an assessment of what is known and what is required to establish the feasibility of applying a technology. The level of development of the technology should be considered (has the process, technique or material been studied or used previously, and if so with what results?). The characteristics of the liquid, slurry, or solid wastes and the site itself should be factored into the decision. The cost savings expected from minimizing the risk of failure at full scale should also be quantified and considered in the decision.

The scope of bench and pilot studies is also an iterative process that progresses through the development of the FS and selected remedial alternative design and construction. Bench and pilot studies conducted in the RI may range from limited treatability (bench) studies to screen general technology types in the FS, to pilot studies to fully evaluate particular alternatives to the FS. In the design and construction stages, full scale pilot studies may also be conducted to determine design and operating standards for the remedial alternative selected in the RI/FS process. The EPA Remedial Project Manager must decide the scope and phasing of bench and pilot studies.

A formal process for defining and conducting treatability studies is presented in the logic diagram of Figure 8-1. The initial step consists of specifying the concept to the extent possible, using available information on how the process or material works over the expected range of application conditions and the factors governing or limiting the application. This specification should be based on a literature review, vendor contacts, and past experience. The next step consists of determining the type and specific goals of the study and the level of effort needed. Once these factors are determined, a complete test plan or SOW is prepared, which contains all information needed to perform the study including data management and interpretation guidelines. The tests are then conducted, and the results are tested for reliability and interpreted. Additional testing may be needed after the data are interpreted, necessitating reevaluation of the SOW and additional study, particularly if the application is innovative.

8.2.3 Example Testing Programs

Table 8-2 illustrates the diversity of activities that may be required to select and apply a remedial technology. The examples of bench and pilot test programs illustrate the diverse disciplines and sciences required to define application conditions for the technologies identified in section 300.70 of the NCP.

8.2.4 Cost Considerations

When deciding the type and extent of studies, cost can be a limiting factor. Pilot-scale studies are significantly more expensive than bench-scale studies, and continuous testing is more expensive than batch testing. As shown in Table 8-1, bench-scale testing may cost 0.5 to 2 percent of the capital cost of an alternative, while pilot-scale studies may require 2 to 5 percent of the capital cost. However, if the capital cost is low (e.g., $100,000 or less), the cost for pilot testing will probably be greater than 5 percent. Therefore, the cost of an extensive testing effort must be weighed carefully in relation to the cost of applying the technology.

8.3 BENCH-SCALE STUDIES

Once the need for a bench-scale study is established, an experimental plan or Statement of Work must be developed. The specific study objectives and the necessary level of detail should be carefully defined. The flexibility and limitations of bench-scale studies must also be considered in the preparation of a test plan.

8.3.1 Preplanning Information Needs

Certain information is required before the planning of a bench-scale study. A waste and site characterization must be completed, preliminary remedial technologies identified, and then information on the alternatives obtained. This information is then used to screen the alternatives and to ascertain if the proposed application is so different from prior applications that process feasibility, efficiency, or material stability cannot be predicted. If this is the case, bench or pilot studies or both are required for the technical analysis portion of the screening procedure.

TABLE 8-2. EXAMPLES OF BENCH AND PILOT SCALE TESTING PROGRAMS

Remedial Technology	Example Testing Programs
A. Air Pollution and Gas Migration Control 1. Capping 2. Dust Control 3. Vapor Collection and Treatment (carbon adsorption)	Bench: Soil density and bearing capacity vs. moisture content curves for proposed capping materials. Pilot: In-place soil densities; determination of gas withdrawal rates to control releases.
B. Surface Water Controls 1. Capping 2. Grading 3. Revegetation 4. Diversion and Collection	Bench: Column testing of capping material compatibility with wastes present. Pilot: In-place testing of geotextiles for control of erosion in grassed diversion ditches.
C. Leachate and Ground-Water Controls 1. Containment barriers (slurry walls, grout curtains, etc.) 2. Ground-water pumping (well points, suction wells, etc.) 3. Subsurface collection drains 4. Permeable treatment beds (limestone, activated carbon) 5. Capping	Bench: Determination of basicity and headloss vs. grain size of limestone materials for a treatment bed. Determination of chemical compatibility of a compacted clay with a leachate stream. Pilot: In-place testing of a soil type and grain size specification and tile drain configuration for a subsurface collection drain.
D. Direct Waste Control 1. Incineration 2. Solidification 3. Biological Treatment • Activated sludge • Facultative lagoons • Trickling filters 4. Chemical Treatment • Oxidation/reduction • Precipitation • Neutralization • Ion exchange resins	Bench: Characterization of chemical and heat content of hazardous waste mixes; chemical, physical, and biological treatability studies to define rate constants, minimal-maximal loading rates and retention times, optimal pH and temperature, sludge generation rates and characteristics, and oxygen transfer characteristics; chemical type and dose rates; solids flux rate vs. solids concentration in sludge

(continued)

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TABLE 8-2. (continued)

Remedial Technology	Example Testing Programs
5. Physical Treatment - Carbon adsorption - Flocculation - Sedimentation - Membrane processes - Dissolved air flotation - Air stripping - Wet air oxidation 6. In-Situ Treatment - Microbial degradation - Neutralization/detoxification - Precipitation - Nitrification 7. Land Disposal (landfill, land application)	thickening systems; air/volume ratios for stripping towers. Pilot: Test burns to determine retention time, combustion chamber and after-burner temperatures, and and fuel makeup requirements for the incineration of a waste. Endurance/performance tests on membranes in reverse osmosis units for ground-water treatment. In-situ microbial degradation testing of nutrient dose and aeration rates to support in-place degradation of contaminants in a plume from an underground leak. Evaluation of in-place mixing procedures for the solidification of a sludge in a lagoon.
E. Soil and Sediment Containment and Removal 1. Excavation 2. Dredging 3. Grading 4. Capping 5. Revegetation	Bench: Determination of soil adsorptive (cation exchange capacity) properties and chemical composition. Pilot: Small-scale dredging to assess sediment resuspension or production rates.

8.3.2 Specification of Objectives and Level of Detail

The objectives of a bench-scale project must be clearly understood from the beginning. Once the objectives of the study are established, the results of the work should be anticipated in selecting the level of study detail. Describing the expected results is essential to defining the variables to be investigated and the range of values for these variables.

Because of the relatively small scale and cost of bench-scale testing, many variables can be evaluated. However, to minimize the testing and to ensure that the work is relevant, the number of variables and range of values tested should be limited so that only those conditions that are anticipated in a full-scale application are evaluated. The impact of each individual variable on technology performance should be evaluated carefully as the final basis for deciding what variables are tested.

8.3.3 Limitations

Bench-scale investigations are flexible, allowing many variables to be evaluated, but certain parameters cannot be tested at the bench-scale level. For example, laboratory equipment simply cannot be configured to resemble the full-scale process. Although certain chemical, biological, and physical reactions may not depend directly on the size and configuration of the reactor, the rates do depend on considerations such as mass, heat, and/or energy transfer, which in turn are affected by the size and configuration. The shortened time scale of bench studies may also be a limitation because the performance capabilities of many technologies cannot be demonstrated without long exposure periods. As a result of these limitations, there are certain technologies for which only pilot-scale testing can be used to develop the information needed to select and define an alternative.

8.3.4 Statement of Work

The experimental plan is documented in a SOW. The SOW should include a clearly defined set of objectives, a detailed work plan by task, a schedule of completion, and a labor-cost estimate. The SOW should also describe or reference all experimental and analytical procedures required, a data management plan, a QA/QC plan, and a health and safety plan.

8.4 PILOT-SCALE STUDIES

Pilot-scale studies generally specify design and operating criteria for the full-scale application after the remedial action alternative has been

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selected. Although pilot studies are of necessity more targeted than bench-scale studies, the same general considerations are included in the test plan.

8.4.1 Preplanning Information Needs

A pilot study usually follows a bench study. If a bench study was not required, the information needed before pilot study planning will include a complete waste and site characterization, a literature review, and an analysis of experience with the technology. However, more detailed information about the process or operation must also be available because pilot work addresses such issues as selection of materials control strategies, installation procedures, and equipment configurations attendant to a final design. Pilot-scale testing is done under operating conditions approximating those expected in the application itself and in a module similar to the full-scale installation.

8.4.2 Specification of Objectives and Level of Detail

The objectives for pilot studies must also be defined rigorously to ensure a successful outcome. Pilot studies are conducted to select an alternative in the RI/FS process or to support design decisions in the design and construction stages or both. Therefore, the variables evaluated should be carefully justified so that each key question is examined and so that reproducible and reliable results are obtained. The variables to be investigated should have a direct impact on full-scale design and operation. Scale-up problems should be recognized before the study begins so that procedures can be incorporated into the test plan to resolve any questions.

8.4.3 Limitations

The flexibility of pilot-scale studies is minimal. Because full-scale operating conditions are to be simulated, pilot systems require the use of actual construction materials and operation over relatively long time periods, often at high cost. Only a few variables can be examined. Conditions for a pilot test should be as close to full-scale conditions as possible, particularly with respect to variation in waste composition. Any deviance from normal conditions must be recorded and considered during data interpretation. The sampling schedule must be designed to map the critical parameters characterizing the technology. In some cases, the period of rapidly changing performance is of more interest than is the period of stable performance. For these reasons, extrapolating data from existing and bench-scale studies may prove more cost-effective than conducting pilot studies. This option should be considered on a case-by-case basis.

Several areas of inquiry can be examined only at the pilot scale. The degree of chemical mixing is especially difficult to evaluate at the bench level, as are methods for the separation, thickening, and dewatering of solids. Pilot investigation is essentially the only means to approximate such methods, short of constructing the prototype. Factors such as hydrodynamics, heat and gas transfer, weather effects, corrosion, and erosion effects, etc., are also usually best tested by pilot studies. Furthermore, skilled judgment is needed to predict the performance of pilot-scale technology from bench-scale data, and prototype performance from pilot data.

8.4.4 Statement of Work

The experimental plan for pilot studies is documented in a Statement of Work (SOW) submitted to the contracting official that should contain all the elements mentioned in the bench-scale study SOW (section 8.3.4). If both bench and pilot studies are conducted, a single SOW may be prepared for both studies and updated after benchwork is completed. However, in many instances it may not be possible to prepare a SOW for pilot studies until the results of the bench studies are available.

8.5 DATA ANALYSIS

The steps in processing bench and pilot study data include data management, data analysis/interpretation, reliability determination, and application of the results. The type and detail of data obtained depend both on the purpose of the study and the type of technology. Different types of data will be generated by testing for process design than by testing for material handling or stability. Process testing at the bench scale is done by tracking effluent characteristics as the parameters are changed in order to determine an optimum operating condition. Material testing involves determining the characteristics of a material after varying exposure periods to varying environments.

8.5.1 Data Management

These data requirements are addressed in section 4.3.5.

8.5.2 Data Analysis and Interpretation

Data analysis and interpretation involve the comparison of anticipated results with actual results to ensure the validity of the assumptions made in planning the study. Major variations between anticipated and actual results may indicate that the objectives of the study cannot be met. In such cases, the SOW must be modified and additional studies performed. However, if the comparison of results shows that the study was properly planned (adequate to

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meet the objectives), graphical and statistical analysis may be used to aid in data interpretation.

Graphical plots of raw experimental results usually illustrate a randomness in the data base that necessitates a statistical analysis in order to focus on the results and to document their validity (Blank, 1980). A statistical analysis can be performed on sample repetitions to determine the significance of the data. However, cost and time limitations often permit only two repetitions to be performed with provisions to conduct a third if the results from the first two tests differ. Sample repetitions of only two or three are difficult to analyze for statistical significance, as a small group is statistically defined as less than 20 samples and is subject to error at even this size.

Fortunately, the results of many types of bench and pilot studies can be graphed to display such trends as isotherms, titration curves, break-through curves, and other correlations dependent on time and concentration. In trend analysis, a rigorous repetitional statistical analysis may not be necessary as random results are more apparent because they stand out from the trend. Correlation analyses are appropriate for determining the consistency of the results and useful in developing kinetic, transfer, and other coefficients from linearized transforms of process or technology performance curves.

8.5.3 Reliability

Analytical procedures can produce major errors if a procedure or instrument is used incorrectly or is not in working order. Inaccuracies also result from the experimental procedure. Additional inaccuracies occur in the measurement of low concentrations because the precision, accuracy, and detection capabilities of the analytical tests are limited. The purpose of the QA/QC plan developed before beginning the testing procedure is to eliminate most if not all of these inaccuracies and ensure reliable results. The ability to justify the performance reliability of a system depends directly on the reliability of the results.

8.5.4 Application of Results

The quantitative data obtained from bench and pilot studies must be converted into useful information. To make the most of the results, the process under consideration must be well understood. This is also true for qualitative data, which are often used in making judgments.

Results from bench and pilot studies can be used in determining a number of criteria. For example, although the primary goal of the studies is to determine technical performance, data can be used to help estimate the cost of the full-scale process. Additional factors such as the complexity of operation, safety, reliability, and projected maintenance requirements can be specified through treatability studies.

The study findings must be evaluated for application to a full-scale technology. The optimum scale-up procedure would be a step-by-step approach, increasing the size of the technology in gradual increments. However, this procedure is much too costly and time-consuming to be used except in the most extreme circumstances. Normally, variables are obtained from the studies, then scaled up using similitude rules and/or mathematical models. Rules of similitude include dynamic, kinematic, and chemical similitude. The studies may also be conducted at full scale but demonstrated on a portion of the site until reliability and operability are proven.

All results, regardless of their use, will ultimately be taken into account in the RI/FS process. Even negative results must be considered so that the conditions producing the negative results are not duplicated at the full scale. Therefore, complete documentation of the study from the preplanning stage to the data reduction stage, including QA/QC and a statistical analysis, is essential to convey all implications of the bench and pilot investigations leading to design recommendations.

CHAPTER 9

REMEDIAL INVESTIGATION REPORT FORMAT

9.1 INTRODUCTION

This chapter presents and discusses the recommended format for reports on remedial investigations conducted under CERCLA. This format has been designed to:

- Ensure that all major issues are adequately addressed
- Produce comparable presentations from different sites
- Promote high quality remedial investigation reports
- Ensure adequate documentation and complete data for use in decisionmaking.

The recommended format will consolidate data from several investigation activities into a single presentation and serve as a checklist of activities conducted and data obtained.

During the remedial investigation process, two reports may be produced depending on site actions anticipated by the Agency:

- Draft and final Remedial Investigation Report (always prepared)
- Endangerment Assessment Report (as needed for enforcement actions).

The draft Remedial Investigation Report is produced at the end of the remedial investigation process. This report characterizes the site and summarizes the data collected and conclusions drawn from all investigative areas and levels. If appropriate, this report may be combined with the associated Feasibility Study Report to provide one site report containing both support data and decisionmaking documentation.

The draft, following review, approval, and revision, becomes the final report. For enforcement-lead actions, the Office of Waste Program Enforcement or an attorney will review the draft report.

An Endangerment Assessment Report is produced only if needed for enforcement cases. This report may be prepared at any level of the RI or the FS and includes contamination, public health, and environmental assessments.

This chapter focuses on the Remedial Investigation Report and discusses what should be included in this report and why.

9.2 FINAL REPORT FORMAT

Table 9-1 presents the recommended Remedial Investigation Report format with the numbering system as it would appear in the report. As described in the preceding section, the report will be prepared for every remedial investigation and will present only the data generated in the investigation to support analysis of remedial alternatives in the feasibility study. As such, it is not intended as a compendium of site information; therefore, all of the sections identified in Table 9-1 may not be relevant to a given investigation. The report contents should be adjusted based on the focus of the data collection and the analyses conducted.

Contaminant levels in the environment will be reported on a mediaspecific basis. For example, contaminant levels in sediments will be presented in the surface-water investigation section, while contaminant concentrations in ground water will be presented in the hydrogeologic investigation section.

For enforcement-lead investigations, the Remedial Investigation Report format may be different. In such instances, close coordination with regional enforcement personnel is necessary to determine the appropriate format and content for the report.

The remaining sections explain each of the sections that may appear in the Remedial Investigation Report.

9.2.1 Executive Summary

The Executive Summary provides a brief overview of the remedial investigation and the data collected by the investigation. Key information about the site and major investigation findings are summarized so the reader is presented with an instant picture of the site and its problems.

The five major areas addressed in the Executive Summary are:

- Purpose of the remedial investigation
- Site description, background, and problems
- Direction and activities of each investigation phase
- Major findings
- Data problems and unresolved data needs.

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TABLE 9-1. REMEDIAL INVESTIGATION REPORT FORMAT

EXECUTIVE SUMMARY

1.0 INTRODUCTION

- 1.1 SITE BACKGROUND INFORMATION
- 1.2 NATURE AND EXTENT OF PROBLEM(S)
- 1.3 REMEDIAL INVESTIGATION SUMMARY
- 1.4 OVERVIEW OF REPORT

2.0 SITE FEATURES INVESTIGATION

- 2.1 DEMOGRAPHY
- 2.2 LAND USE
- 2.3 NATURAL RESOURCES
- 2.4 CLIMATOLOGY

3.0 HAZARDOUS SUBSTANCES INVESTIGATION

- 3.1 WASTE TYPES
- 3.2 WASTE COMPONENT CHARACTERISTICS AND BEHAVIOR

4.0 HYDROGEOLOGIC INVESTIGATION

- 4.1 SOILS
- 4.2 GEOLOGY
- 4.3 GROUND WATER

5.0 SURFACE-WATER INVESTIGATION

- 5.1 SURFACE WATER
- 5.2 SEDIMENTS
- 5.3 FLOOD POTENTIAL
- 5.4 DRAINAGE

6.0 AIR INVESTIGATION

(continued)

TABLE 9-1. (continued)

7.0 BIOTA INVESTIGATION

    7.1 FLORA
    7.2 FAUNA

8.0 BENCH AND PILOT TESTS

9.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

    9.1 POTENTIAL RECEPTORS
    9.2 PUBLIC HEALTH IMPACTS
    9.3 ENVIRONMENTAL IMPACTS

REFERENCES

APPENDICES

Specific elements addressed under each of the major areas briefly convey the important characteristics and findings. Tables and figures are used where possible to summarize information clearly and concisely. The suggested length of the Executive Summary is five pages with, at most, one or two tables or figures.

9.2.2 Introduction

As the introduction to the Remedial Investigation Report, chapter 1 briefly characterizes the site, which establishes a background for the data collection and analysis activities. The Introduction addresses four major areas: (1) site background information; (2) the nature and extent of contamination problem(s) at the site; (3) investigation objectives and activities; and (4) an overview of the report contents. These discussions review the key features, conditions, and parameters of the site that are essential to analysis of site problems and selection of remedial action alternatives.

9.2.2.1 Site Background Information

Included in the site background discussion are brief descriptions of past and existing activities at the site, particularly the current physical, biological, and socioeconomic factors. Specific elements that may be addressed in this section of the introduction include:

- Facility location, size, configuration, existing structures
- Timeframe of waste-related activities
- Historical description of:
    - facility type
    - activities and operations
    - types of wastes
    - condition of wastes (originally as well as at present)
    - incidents (fire, explosion, ground-water contamination, etc.)
    - site investigations, sampling, regulatory violations, response actions, and enforcement activities
    - ownership
- Physiography
- Other factors including
    - community perception
    - planned use of site
    - conflicting or missing information
    - site map showing location, size, water supplies, sensitive environmental areas, and nearby populations.

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All discussions should pertain to the use of the facility for management of hazardous wastes.

9.2.2.2 Nature and Extent of the Problem

The discussion of the nature and extent of the problem(s) at the site should concentrate on the materials present and current contamination problems. This defines a framework for determining the remedial action objectives and for selecting appropriate remedial action alternatives.

This "problems" section of the introduction focuses on existing and potential on-site and off-site contamination problems and effects. It should include the following:

- Type, physical state, and quantity of wastes or hazardous substances on-site
- Special waste considerations (explosive, radioactive, etc.)
- Present condition of materials and structures (including drums, tanks, landfills, etc.)
- Changes in site (e.g., filling in a waste pit or lagoon, applying cover material to buried or semi-buried drums)
- Effects of contaminants from the site (drawing on monitoring and geotechnical studies):
  - types of contaminant release (leachate, runoff, etc.)
  - affected media, movement of contaminants, direction of movement
  - resources, population, or environments threatened or harmed by contaminant movement
  - human exposure
- Near-future impacts of site conditions and contaminant migration (subsurface, surface, and atmospheric)
- Actions previously taken to mitigate problems and the result(s) of these actions.

These discussions should describe the threat or potential threat to public health, welfare, or the environment from the site.

9.2.2.3 Investigation Summary

The investigation summary identifies the objective(s) of each level and activity of the remedial investigation. This section also provides an overview of the investigations conducted.

9.2.2.4 Overview of Report

This section presents an overview of the remainder of the report, briefly describing the contents of each chapter.

9.2.3 Site Features Investigation

Chapter 2 presents the results of the investigation of the features of the site. At least four sections are included:

- Demography
- Land use
- Natural resources
- Climatology.

Other site feature data may be presented in additional sections as necessary. Only those site features investigated should be described.

Each section should describe the key parameters investigated and analyzed for the site and include information pertinent to technical, public health, and environmental analyses conducted in the feasibility study, particularly those elements affecting the applicability of the remedial alternatives being considered. For example, the investigation may have identified the proximity of waste sources to public wells or National/State forest lands; this information would be presented as part of the natural resources section.

9.2.4 Hazardous Substances Investigation

Chapter 3 presents data from investigations of the wastes found on-site. This chapter is divided into two parts:

- Waste types
- Waste component characteristics and behavior.

The first subsection addresses waste quantities, location, components, containment, and composition. It covers all the materials at the site that are sources of environmental contamination or public health threat, or may be disturbed, removed, or treated, or may be "in the way" in a remedial action. This information will not only aid in selecting a remedial alternative but may also affect the design and planning of remedial actions (e.g., health and safety considerations).

The second subsection summarizes the results of the investigation of waste component characteristics, including testing results for waste constituent toxicity, bioaccumulation, metabolism, environmental transformation, or other characteristics. These data are used in the public health and environmental assessments and analyses conducted in the RI/FS.

9.2.5 Hydrogeologic Investigation

Chapter 4 presents the results of the hydrogeologic investigation. This chapter includes at least three major sections:

- Soils
- Geology
- Ground water.

Additional sections may be included if needed to present hydrogeologic and contamination problems at the site.

The soil analyses include all soils data and descriptions that characterize the site and affect decisions on remedial alternatives. Data to be included are soil types, depths, content and characteristics (e.g., clay content), and contamination levels.

The geology section presents the geologic features and characteristics identified in the investigation. The focus is on site geology and subsurface features as well as contaminant levels that may be useful in characterizing site problems and potential impacts and in choosing remedial solutions.

The section on ground water addresses direction of ground-water flow, dimensions of contaminant plume, plume migration, and aquifer systems underlying the site. This section also identifies contaminant levels.

9.2.6 Surface-Water Investigation

The focus in chapter 5 is on surface-water investigations and analyses. At least four major subsections are included:

- Surface-water bodies
- Sediments
- Flood potential
- Drainage.

Additional subsections may be added to address the surface-water hydrologic and contamination features of the site.

For the investigations conducted, each subsection presents the results of data analysis and supporting raw data. For example, the section on surface-water bodies addresses the extent of contamination (spread from site), contaminant migration, and surface-water flow. The sediments section describes concentration variations of contaminants with sediment depth, sediment particulate size, and the dimensions of contaminant location in sediments. Similarly, the flood potential subsection focuses on the location of the site in a floodplain, and the drainage subsection addresses surface-water and precipitation drainage across the site. Descriptions of all these site features provide data for environmental, public health, and technological assessments in the feasibility study.

9.2.7 Air Investigation

Chapter 6 presents the results of the air investigation, including data on air concentrations of contaminants, contaminant plume dimensions and movement, and airborne particulates. The results of other air investigations and analyses conducted to define site problems and select and design a remedial alternative are also presented here.

9.2.8 Biota Investigation

Chapter 7 focuses on the contaminant levels found in site flora and fauna. Resident endangered species are also identified. These data contribute to environmental analyses and assessments of present site conditions and to the selection of remedial alternatives in the feasibility study.

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9.2.9 Bench and Pilot Studies

Chapter 8 identifies and presents the results of bench and pilot tests conducted in the remedial investigation. These tests may be conducted to provide data for remedial alternative selection or design. Each different test series should be treated independently (i.e., soils studies, treatment efficiencies, and compatibility tests would be presented separately). For each test series, testing objectives, results, and analyses should be presented, with conclusions clearly stated.

9.2.10 Public Health and Environmental Concerns

Chapter 9 presents a discussion of potential public health and environmental impacts. This chapter consists of three subsections:

- Potential receptors
- Public health
- Environmental impacts.

The potential receptors subsection identifies human and other receptors (flora, fauna), including endangered species, that are or may be affected by site contamination. The subsection on public health summarizes public health concerns resulting from site contaminants and contaminated areas or resources. The environmental impacts subsection reviews environmental damage from the site. Together, this information will contribute to the determination of remedial action objectives for the site.

9.2.11 References

The reference section contains complete bibliographic citations for information sources used and cited in the main text of the report. References for information sources cited in an appendix should appear in that appendix.

9.2.12 Appendices

The text of the Remedial Investigation Report summarizes the site information collected and analyzed in the investigation process. To focus this summary so that it presents the critical site characteristics and major analysis features clearly and logically, detailed discussions, diagrams, sampling data, maps, computer modeling results, and other supporting data and analyses may best be presented as appendices to the main report. As many appendices as needed may be added.

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APPENDIX A

MODEL STATEMENT OF WORK FOR CONDUCTING REMEDIAL INVESTIGATIONS

PURPOSE

The purpose of this remedial investigation is to determine the nature and extent of the problem at the site and to gather all necessary data to support the feasibility study. The Engineer will furnish all personnel, materials, and services necessary for, or incidental to, performing the remedial investigation at [specific site], an uncontrolled hazardous waste site.

SCOPE

The remedial investigation consists of seven tasks[1]:

Task 1 - Description of Current Situation
Task 2 - Plans and Management
Task 3 - Site Investigation
Task 4 - Site Investigation Analysis
Task 5 - Laboratory and Bench-Scale Studies
Task 6 - Reports
Task 7 - Community Relations Support

TASK 1 - DESCRIPTION OF CURRENT SITUATION

Describe the background information pertinent to the site and its problems and outline the purpose for remedial investigation at the site. The data gathered during any previous investigations or inspections and other relevant data should be used.

This task may be conducted concurrently with Task 2, development of the work plan.

a. Site Background

Prepare a summary of the Regional location, pertinent area boundary features, and general site physiography, hydrology, and geology.

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[1] The Remedial Investigation guidance should be consulted for additional information on the tasks listed below.

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Define the total area of the site and the general nature of the problem, including pertinent history relative to the use of the site for hazardous waste disposal.

b. Nature and Extent of Problem

Prepare a summary of the actual and potential on-site and off-site health and environmental effects. This may include, but is not limited to, the types, physical states, and amounts of the hazardous substances; the existence and conditions of drums, landfills, and lagoons [substitute site-specific features if different]; affected media and pathways of exposure; contaminated releases such as leachate or runoff; and any human exposure. Emphasis should be placed on describing the threat or potential threat to public health and the environment.

c. History of Response Actions

Prepare a summary of any previous response actions conducted by either local, State, Federal, or private parties, including the site inspection and other technical reports, and their results. This summary should address any enforcement activities undertaken to identify responsible parties, compel private cleanup, and recover costs. A list of reference documents and their location shall be included. The scope of the remedial investigation should be developed to address the problems and questions that have resulted from previous work at the site.

d. Site Visit

Conduct an initial site visit to become familiar with site topography, access routes, and proximity of receptors to possible contamination and collect data for preparation of the site safety plan. The visit should be used to verify the site information developed in this Task.

e. Define Boundary Conditions

Establish site boundary conditions to limit the areas of site investigations. The boundary conditions should be set so that subsequent investigations will cover the contaminated media in sufficient detail to support following activities (e.g., the feasibility study). The boundary conditions may also be used to identify boundaries for site access control and site security. [If not in existence, installation of a fence or other security measures should be considered.]

f. Site Map

Prepare a site map showing all wetlands, floodplains, water features, drainage patterns, tanks, buildings, utilities, paved areas, easements, rights-of-way, and other features. The site map and all topographical surveys should be of sufficient detail and accuracy to locate and report all existing and future work performed at the site. [Permanent baseline monuments, bench marks, and reference grid tied into any existing reference system (i.e., State or USGS) should be considered as an option.]

g. Site Office

If agreed to by EPA and the State, establish a temporary site office to support site work.

h. Contractor Procurement

[When SOW is used for Federal-lead, change to "Subcontractor Procurement" and modify as required.] Prepare contractor procurement documents and award subagreement to secure the services necessary to conduct the remedial investigation and feasibility study.

TASK 2 - PLANS AND MANAGEMENT

Prepare all necessary plans for the remedial investigation. The work plan should include a detailed discussion of the technical approach, budget, personnel requirements, and schedules, as well as the following:

a. Sampling Plan

Prepare a Sampling Plan to address all field activities to obtain additional site data. The plan will contain a statement of sampling objectives; specification of equipment, analyses of interest, sample types, and sample locations and frequency; and schedule. Consider use of field screening techniques to screen out samples that do not require off-site laboratory analysis. The plan will also include a quality assurance and quality control plan with documentation requirements and estimates of costs and labor. The plan must address all levels of the investigation as well as all types of investigations conducted (e.g., waste characterization, hydrogeologic, soils and sediments, air and surface water). The plan will identify potential remedial technologies and associated data that may be needed to evaluate alternatives for the feasibility study.

b. Health and Safety Plan

Prepare a Health and Safety Plan to address hazards that the investigation activities may present to the investigation team and to the surrounding community. The plan should address all applicable regulatory requirements and detail personnel responsibilities, protective equipment, procedures and protocols, decontamination, training, and medical surveillance. The plan should identify problems or hazards that may be encountered and their solutions. Procedures for protecting third parties, such as visitors or the surrounding community, will also be provided.

c. Data Management Plan

Develop and initiate a Data Management Plan to document and track investigation data and results. This plan should identify and set up laboratory and data documentation materials and procedures, project file requirements, and project-related progress and financial reporting procedures and documents.

d. Community Relations Plan

Prepare a plan, based on on-site discussions, for the dissemination of information to the public regarding investigation activities and results. Opportunities for comment and input by citizen, community and other groups must also be identified and incorporated into the plan. Staffing and budget requirements for implementation also must be included. [Not required if Community Relations Plan has been prepared.]

TASK 3 - SITE INVESTIGATION

Conduct only those investigations necessary to characterize the site and its actual or potential hazard to public health and the environment. The investigations should result in data of adequate technical content to support the development and evaluation of remedial alternatives during the feasibility study. Investigation activities will focus on problem definition and data to support the screening of remedial technologies, alternative development and screening, and detailed evaluation of alternatives.

The site investigation activities will follow the plans set forth in Task 2. All sample analyses will be conducted at laboratories following EPA protocols or their equivalents. Strict chain-of-custody procedures will be followed and all samples will be located on the site map [and grid system] established under Tasks 1 and 2.

a. Waste Characteriziation

Conduct a sampling and analysis program to characterize all materials of interest at the site. These materials should include wastes stored above or below ground in tanks, drums, lagoons, piles, or other structures.

b. Hydrogeologic Investigation

[Generally limited to investigations for off-site migration.] Conduct a program to determine the presence and potential extent of ground water contamination [and to evaluate the suitability of the site for on-site waste containment].

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[Identify specific aquifer to be studied.] Efforts should begin with a survey of previous hydrogeologic studies and other existing data. The survey should address the degree of hazard, the mobility of pollutants considered (from Waste Characterization), the soils' attenuation capacity and mechanisms, discharge/recharge areas, regional flow directions and quality, and effects of any pumping alternatives that are developed, if applicable. Such information may be available from the USGS, the Soil Conservation Service, and local well drillers. An accompanying sampling program should determine the horizontal and vertical distribution of contaminants and predict the long-term disposition of contaminants.

c. Soils and Sediments Investigation

Conduct a program to determine the location and extent of contamination of surface and subsurface soils and sediments [identify specific areas to be studied]. This process may overlap with certain aspects of the hydrogeologic study (e.g., characteristics of soil strata are relevant to both the transport of contaminants by ground water and to the location of contaminants in the soil; cores from ground water monitoring wells may serve as soil samples). A survey of existing data on soils and sediments may be useful. The horizontal and vertical extent of contaminated soils and sediments should be determined. Information on local background levels, degree of hazard, location of samples, techniques utilized, and methods of analysis should be included. The investigation should identify the locations and probable quantities of subsurface wastes, such as buried drums, through the use of appropriate geophysical methods.

d. Surface Water Investigation

Conduct a program to determine the extent of contamination of [identify specific water bodies]. This process may overlap with the soils and sediments investigation; data from stream or lake sediments sampled may be relevant to surface water quality. A survey of existing data on surface water flow quantity and quality may be a useful first step, particularly information on local background levels, location and frequency of samples, sampling techniques, and method of analysis.

e. Air Investigation

Conduct a program to determine the extent of atmospheric contamination. The program should address the tendency of substances (identified through Waste Characterization) to enter the atmosphere, local wind patterns, and the degree of hazard.

[Note: Other categories of investigations may be needed for specialized site problems. These could include biological and radiological investigations.]

TASK 4 - SITE INVESTIGATION ANALYSIS

Prepare a thorough analysis and summary of all site investigations and their results. The objective of this task will be to ensure that the investigation data are sufficient in quality (e.g., QA/QC procedures have been followed) and quantity to support the feasibility study.

The results and data from all site investigations must be organized and presented logically so that the relationships between site investigations for each medium are apparent. Analyze all site investigation data and develop a summary of the type and extent of contamination at the site. The summary should describe the quantities and concentrations of specific chemicals at the site and ambient levels surrounding the site. Describe the number, locations, and types of nearby populations and activities and pathways that may result in an actual or potential threat to public health, welfare, or the environment. [Specify whether a contamination, public health, and/or environmental assessment is to be conducted.]

TASK 5 - LABORATORY AND BENCH-SCALE STUDIES

[Note: The following applies when additional studies are necessary to fully evaluate remedial alternatives. The paragraphs may be modified to meet specific project conditions.]

Conduct laboratory and/or bench-scale studies to determine the applicability of remedial technologies to site conditions and problems. Analyze the technologies, based on literature review, vendor contacts, and past experience to determine the testing requirements.

Develop a testing plan identifying the type(s) and goal(s) of the study(ies), the level of effort needed, and data management and interpretation guidelines for submission to [specify EPA and State recipients] for review and approval.

Upon completion of the testing, evaluate the testing results to assess the technologies with respect to the site-specific questions identified in the test plan. Scale up those technologies selected based on testing results.

Prepare a report summarizing the testing program and its results, both positive and negative.

TASK 6 - REPORTS

a. Progress Reporting Requirements

[Note: The following paragraph applies when the SOW is being used in a contract between the State and an Engineer. Typical requirements are described but may be modified based on the size and complexity of the specific project. When the SOW is used in a Cooperative Agreement, this section should be replaced with reporting requirements consistent with 40 CFR Part 30 and the guidance "State Participation in the Superfund Remedial Program," February 1984.]

Monthly reports shall be prepared by the Engineer to describe the technical and financial progress of the project. These reports should discuss the following items:

1. Identification of site and activity
2. Status of work at the site and progress to date
3. Percentage of completion and schedule status

4. Difficulties encountered during the reporting period
5. Actions being taken to rectify problems
6. Activities planned for the next month
7. Changes in personnel
8. Actual expenditures (including fee) and direct labor hours expended for this period
9. Cumulative expenditures (including fee) and cumulative direct labor hours
10. Projection of expenditures for completing the project, including an explanation of any significant variation from the forecasted target
11. A graphic representation of proposed versus actual expenditures (plus fee) and comparison of actual versus target direct labor hours. A projection to completion will be made for both.

The monthly progress report will list target and actual completion dates for each element of activity, including project completion, and will provide an explanation of any deviation from the milestones in the work plan.

b. Final Report

Prepare a final report covering the remedial investigation and submit [specify number and distribution] copies to [specify EPA and State recipients, as appropriate]. The report shall include the results of Tasks 1 through 5, and should include additional information in appendices. The report shall be structured to enable the reader to cross-reference with ease.

TASK 7 - COMMUNITY RELATIONS SUPPORT

[Note: The following paragraph applies when community relations support is conducted under the work covered in this SOW (e.g., under a Cooperative Agreement). The paragraph may be modified to meet specific site or project conditions.]

The Engineer may be required to furnish the personnel, services, materials, and equipment to undertake a community relations program. Although this may be a limited program, community relations must be integrated closely with all remedial response activities. The objectives of this effort are to achieve community understanding of the actions taken and to obtain community input and support prior to selection of the remedial alternative(s).

Community relations support should include, but may not be limited to, the following:

- Revisions or additions to community relations plans, including definition of community relations program needs for each remedial activity
- Analysis of community attitudes toward the proposed actions
- Preparation and dissemination of news releases, fact sheets, slide shows, exhibits, and other audio-visual materials designed to apprise the community of current or proposed actions
- Establishment of a community information center
- Arrangements of briefings, press conferences, workshops, and public and other informal meetings
- Assessment of the successes and failures of the community relations program
- Preparation of reports and participation in public meetings, project review meetings, and other meetings as necessary to the normal progress of the work
- Solicitation, selection, and approval of subcontractors, if needed.

All community relations support must be consistent with Superfund community relations policy, as stated in the "Guidance for Implementing the Superfund Program" and Community Relations in Superfund -- A Handbook.

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